NASA Marshall Space Flight Center

(NASA-TM-82254) THE MARSHALL CENTER: ITS PLACE IN NASA (NASA) 31 p HC A03/MF A01 CSCL 05A

N81-17958

Unclas

G3/85 13515

Dr. William R. Lucas, director of the Marshall Center since 1974

With the coming of NASA's Space Shuttle, new and almost limitless horizons have been opened up to us. Space is seen no longer as only a realm to explore; it is viewed more as a bright and limitless natural resource from which can be derived important benefits on Earth. In many ways we are just now on the threshold of what future generations will come to consider the Age of Space.

We at the Marshall Space Flight Center are proud to have an important role in the development of this Space Transportation System. We are also deeply involved in application of space science and technology, not only in space but also to Earth processes as well. This broad-based capability, developed over many years, has prepared the Center for continued participation in programs of the future. As we identify needs that can be met through the use of space, or space technology, we will move to meet them.

The purpose of this booklet is to show you how the Marshall Center fits into the framework of the nation's hopes and plans for the future in space, and to stress the importance of our employees' contributions to our wide-ranging activities. After reading this, we think you will see why the Marshall Space Flight Center is considered to be one of the finest scientific and engineering institutions in the world.

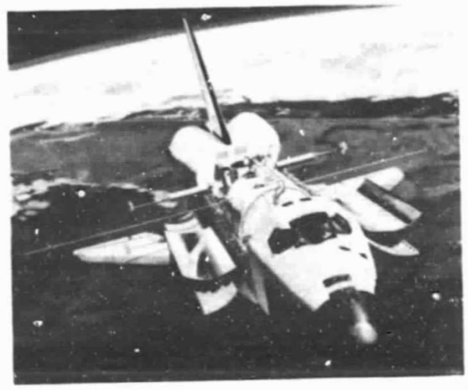
W. R. Lucas

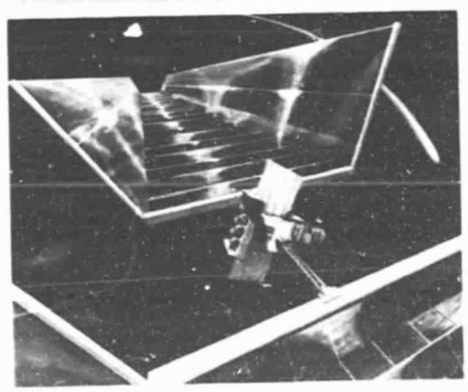
W. R. Lucas
Director

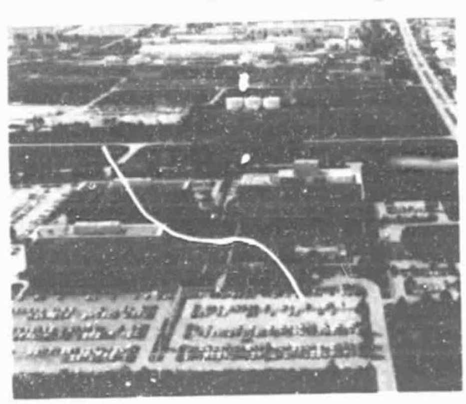
NASA
National Aeronautics and
Space Administration

George C. Marshall Space Flight Center

CONTENTS



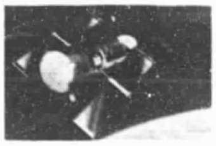




THE MARSHALL CENTER: ITS PLACE IN NASA

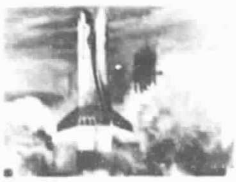
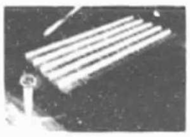
CURRENT DEVELOPMENT PROJECTS



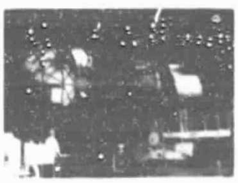


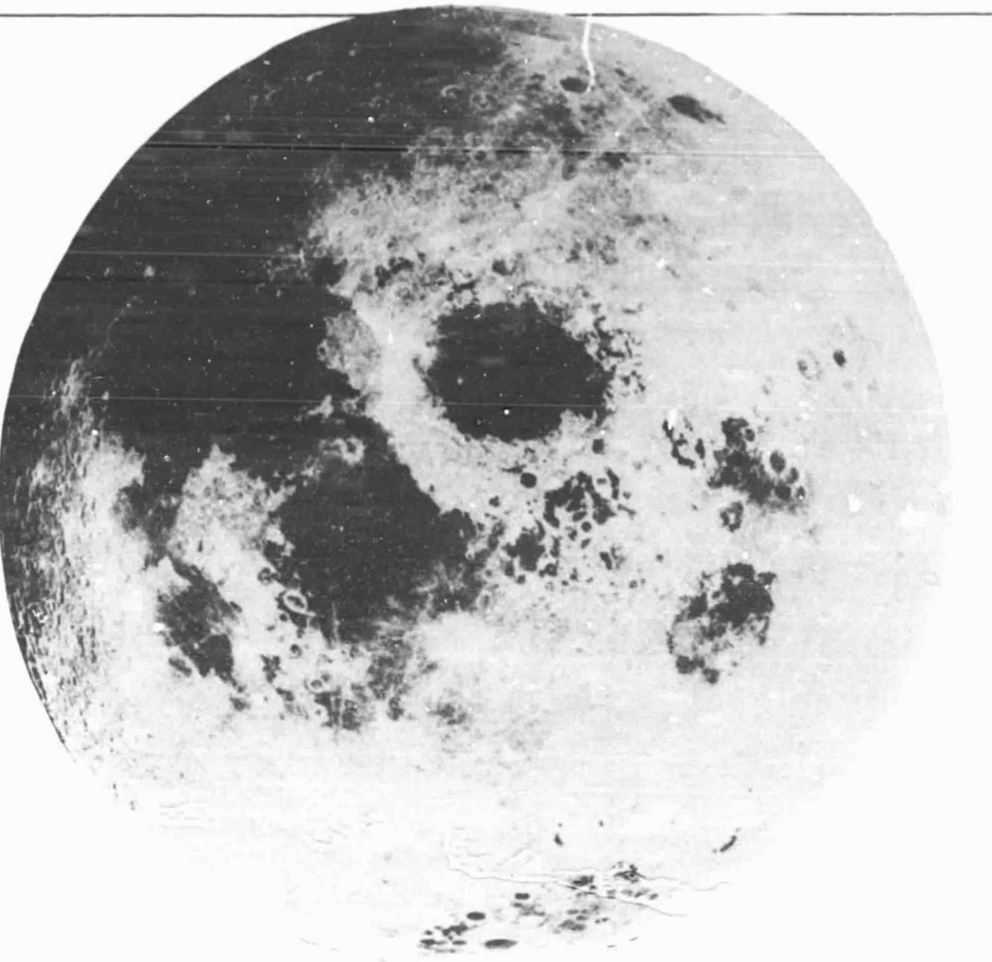

PROBING THE FUTURE



MANAGEMENT AND RESOURCES



THE MARSHALL CENTER: Its Place in NASA

The Marshall Space Flight Center, one of NASA's largest facilities, is located just southwest of Huntsville, Alabama, on an 1840-acre tract bordered on the south by the Tennessee River.

In the past, the division of responsibility for manned space flight gave the Marshall Center the role of developer of NASA's propulsion systems. But in its two decades at the forefront of space exploration, the Center has gained a wide range of experience and capabilities in spacecraft and experiment development as well as in rocket propulsion systems.

Marshall is one of the nation's pioneering space centers, born of the Redstone team of rocket pioneers headed by Dr. Wernher von Braun. Before joining NASA in 1960, this group had already pioneered the development of reentry protection for spacecraft and had built the early Army rocket that launched America's first satellites and was soon to carry the nation's first astronauts into space. When these engineers and scientists formed the nucleus of the new Marshall Space Flight Center, they brought with them their already-moving program to build a family of giant launch vehicles that became known as the Saturns.

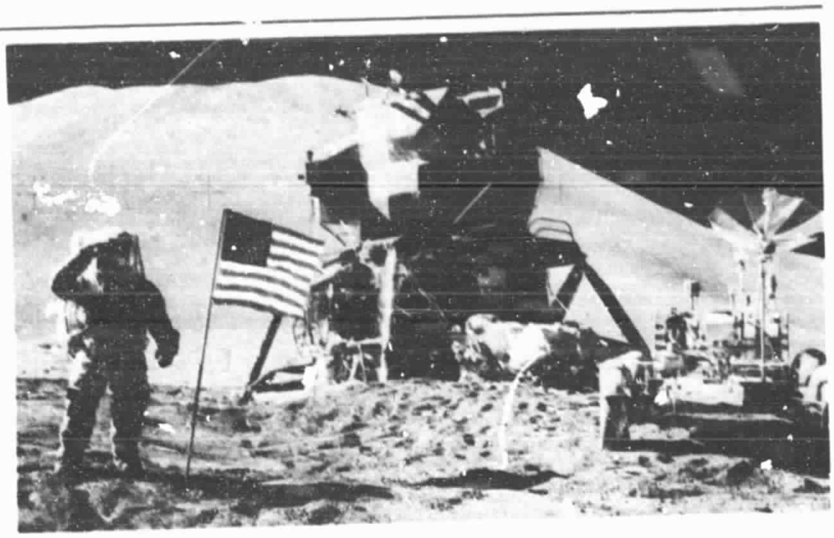
In May of 1961, President John F. Kennedy set an ambitious goal for the nation: to land a man on the moon and return him safely to Earth by the end of the decade. This direction accelerated a Marshall Center program that in only six years produced the most powerful rocket ever built, the Saturn V which, with its lunar space craft, stood 363 feet tall.

As the Saturn program grew, so did the Marshall Center and neighboring Huntsville. Aerospace contractors came to the area with great numbers of people to work on the Saturn I, Saturn IB and Saturn V — some major elements of which were manufactured at the Center.

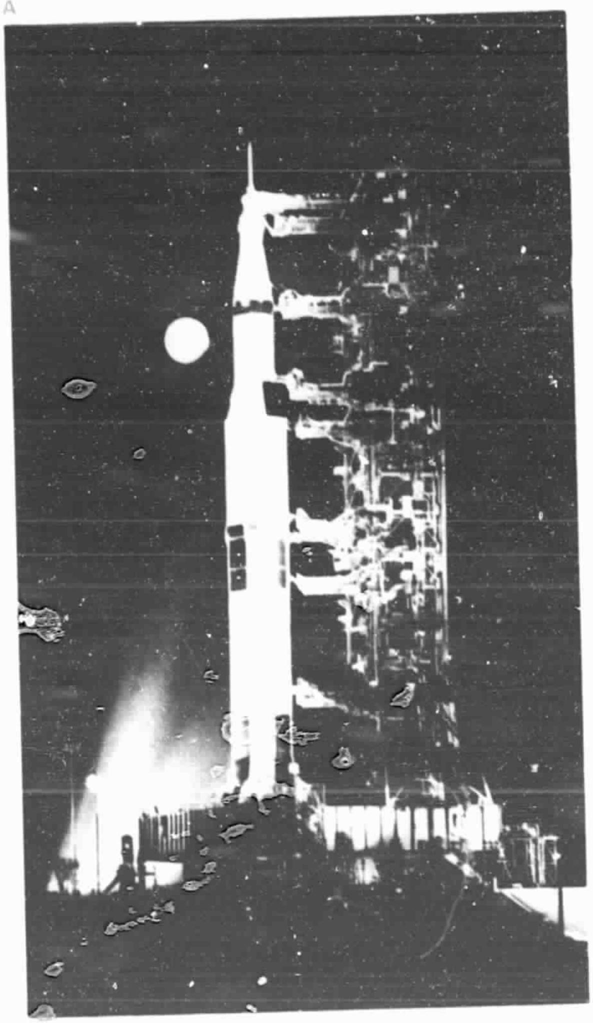
After the initial success of the Saturns came the urgent project to develop a Lunar Roving Vehicle, the unique machine that turned America's lunar visitors into far-ranging lunar explorers. The Marshall Center was also responsible for the development of man's first orbiting laboratory, Skylab.

These historic projects provided the Marshall Center with a legacy of experience and facilities that enabled it to take on a wide variety of new space challenges like those provided today by the Space Shuttle, Spacelab, Space Telescope, and a host of other projects that this book will discuss.

B



A



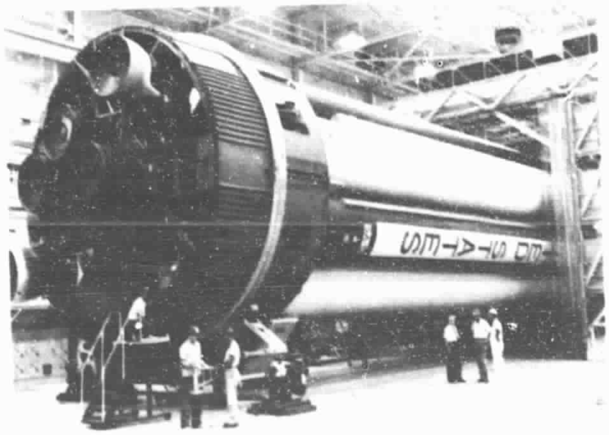
A The Marshall Center's Saturn V boosted Apollo 11 crew to the moon.

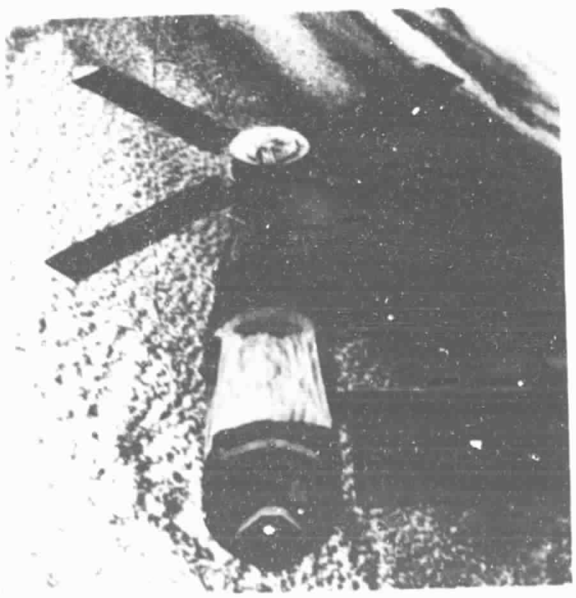
B Three Apollo teams explored the moon [illegible]

C [illegible] together in Marshall assembly facility.

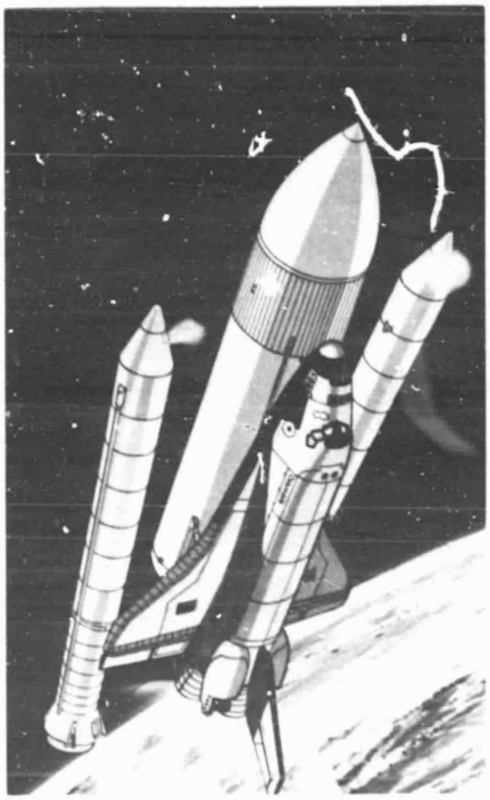
D [illegible]

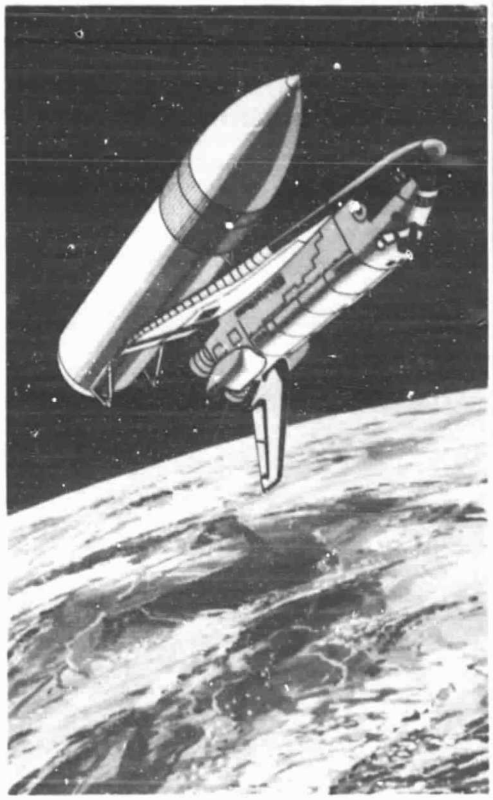
C

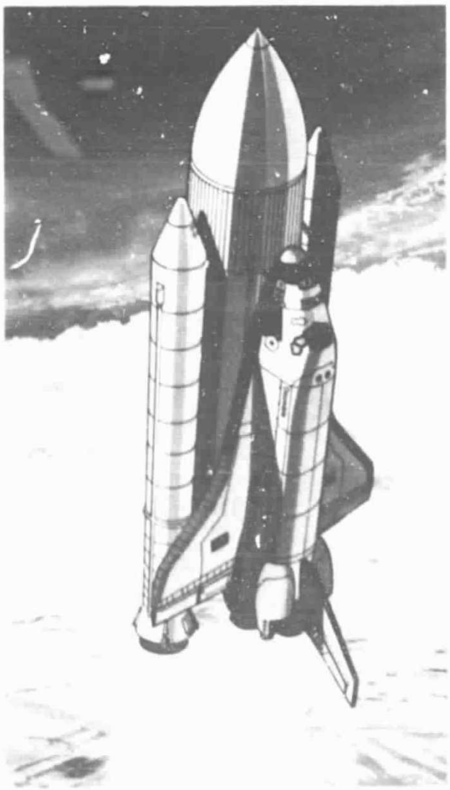




CURRENT DEVELO







The Space Transportation System

The Space Shuttle, heart of the agency's new space transportation system, markedly expands man's ability to do things in space at lower cost, more often, and more effectively than ever before.

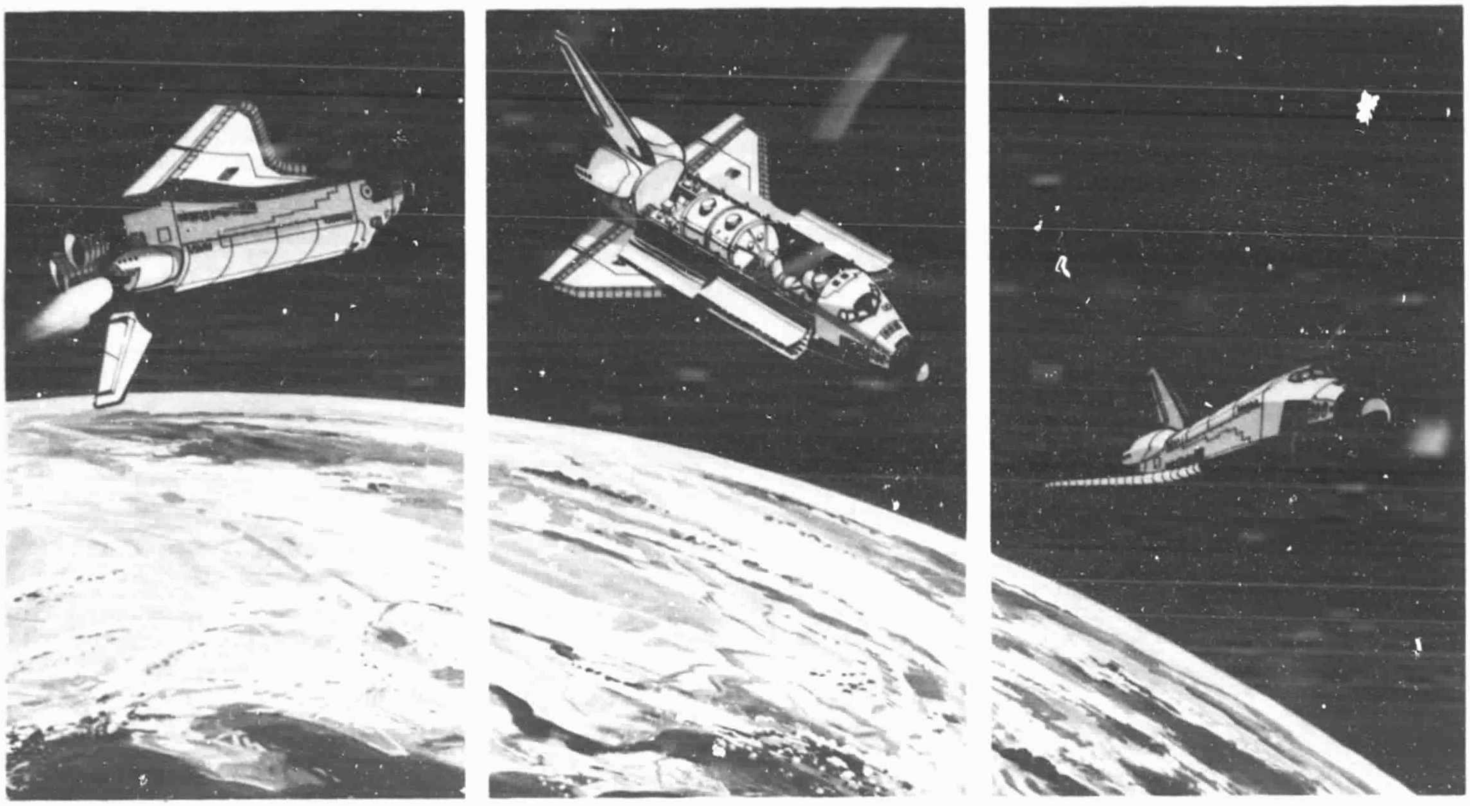
What makes the Shuttle so different is its reusability. It is launched like a conventional rocket, operates in orbit and reenters like a spacecraft, then glides back to Earth for an airplane-like runway landing. Then, after minor refurbishment, the Shuttle is reassembled and launched again.

The Shuttle is actually a collection of several major elements. The *Orbiter* is the airplane-like component which carries the payload and the crew. The *External Tank* carries the Shuttle's liquid propellants and serves as the backbone of the whole craft. Strapped to each side of the tank is a *Solid Rocket Booster* which provides thrust at liftoff and early in flight. The orbiter's three *Space Shuttle Main Engines* fire in unison with the two big boosters to lift the combined craft off its pad and thrust it towards orbit.

About two minutes into the eight minutes of powered flight, the solid fuel in the boosters is expended. Small rockets fire in the booster's nose and tail sections, pushing them away from the rest of the rapidly accelerating Shuttle. The boosters descend on parachutes into the ocean where they are retrieved and later refurbished for use on another flight.

The Orbiter and the External Tank continue until, just before orbital velocity is achieved, the tank

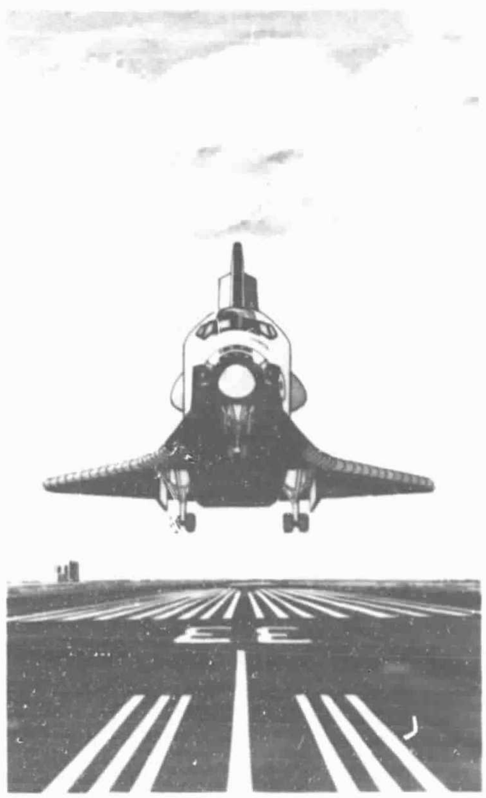
PMENT PROJECTS

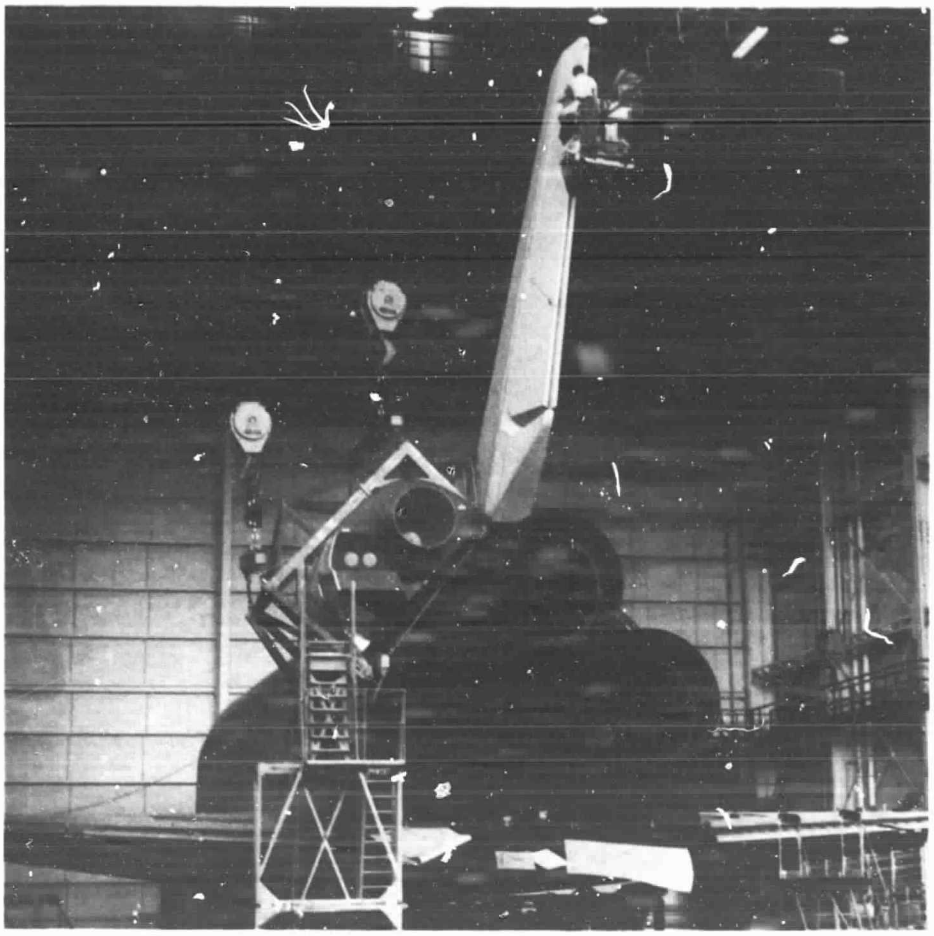


is almost emptied of its liquid hydrogen and liquid oxygen load. At that point, the main engines shut down and the tank is jettisoned to tumble back to Earth and break up over the Indian Ocean. This is the only Shuttle element that was not designed to be recovered and reused. The Orbiter gets its final push into orbit from two small maneuvering rockets carried high in its tail.

Once parked in orbit around the Earth, the Shuttle Orbiter's big cargo bay doors open to reveal its cargo: instruments to be operated in place, satellites to be deposited in space, or planetary spacecraft to be launched on distant journeys. On some missions, the Orbiter's boxcar-size cargo bay will hold a unique facility called Spacelab, from which scientists can study both the space environment and the Earth below. They can also perform vital research in such areas as the processing of materials and the study of weather-making mechanisms in the clouds — both of which are made possible only by the low-gravity conditions that operating in space provides.

The Marshall Center has been heavily involved for years in the development and testing of this new craft. Of the principal elements just described — the Orbiter, Main Engines, External Tank, and Solid Rocket Boosters — this Center has had responsibility for managing the development of all but the Orbiter itself.



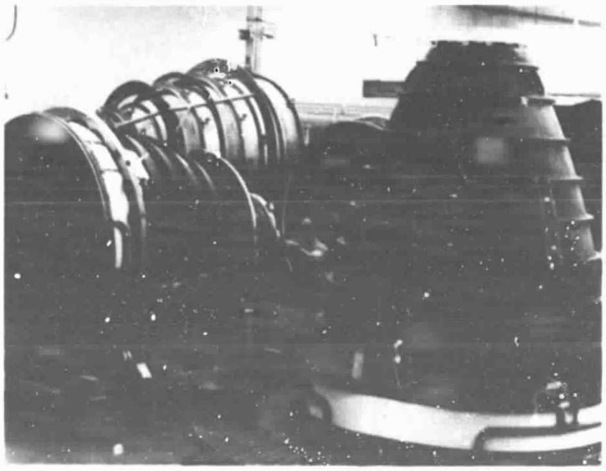


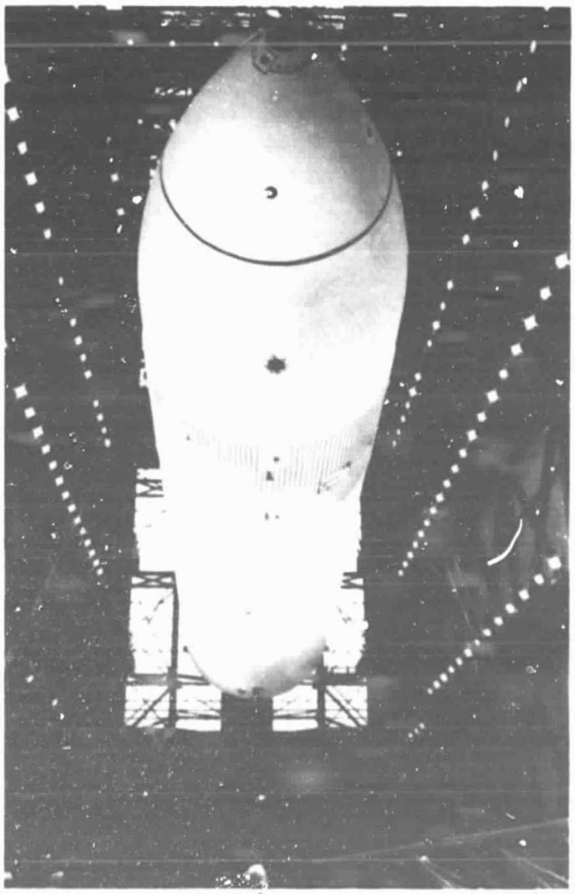
The Shuttle's complement of three main engines

Space Shuttle Main Engine

The Space Shuttle is powered by three advanced design, high pressure liquid rocket engines mounted in the Orbiter's tail section. Each engine provides 470,000 pounds of thrust. These engines developed by the Marshall Center and its prime contractor, the Rocketdyne Division of Rockwell International, each consume 64,000 gallons of liquid hydrogen and liquid oxygen per minute during flight.

When the Shuttle engine is compared with the Saturn engines developed by Marshall previously, it becomes apparent that the requirements established for this new engine generated significant design challenges. The Saturn engine flew only once, for a lifetime of no more than ten minutes. The Shuttle's engine had to be designed to fly again and again — for a minimum





of 55 flights and a design life of 7.5 hours of burn time. Added to this was the requirement that thrust levels be varied over a throttle range of 65 percent to 109 percent of rated thrust during flight, something totally new for manned space vehicle boosters. And to get the efficiency required, combustion chamber pressures three times higher than Saturn's were necessary, bringing unprecedented challenges in the pump design and materials areas.

Obviously, this engine had to be designed to endure higher stresses and thermal levels, and to meet more extensive fatigue and maintenance requirements than any rocket engine built before. The challenges presented by the Space Shuttle Main Engine were recognized from the outset to require the most significant technological advancement of the whole Shuttle program.

External Tank

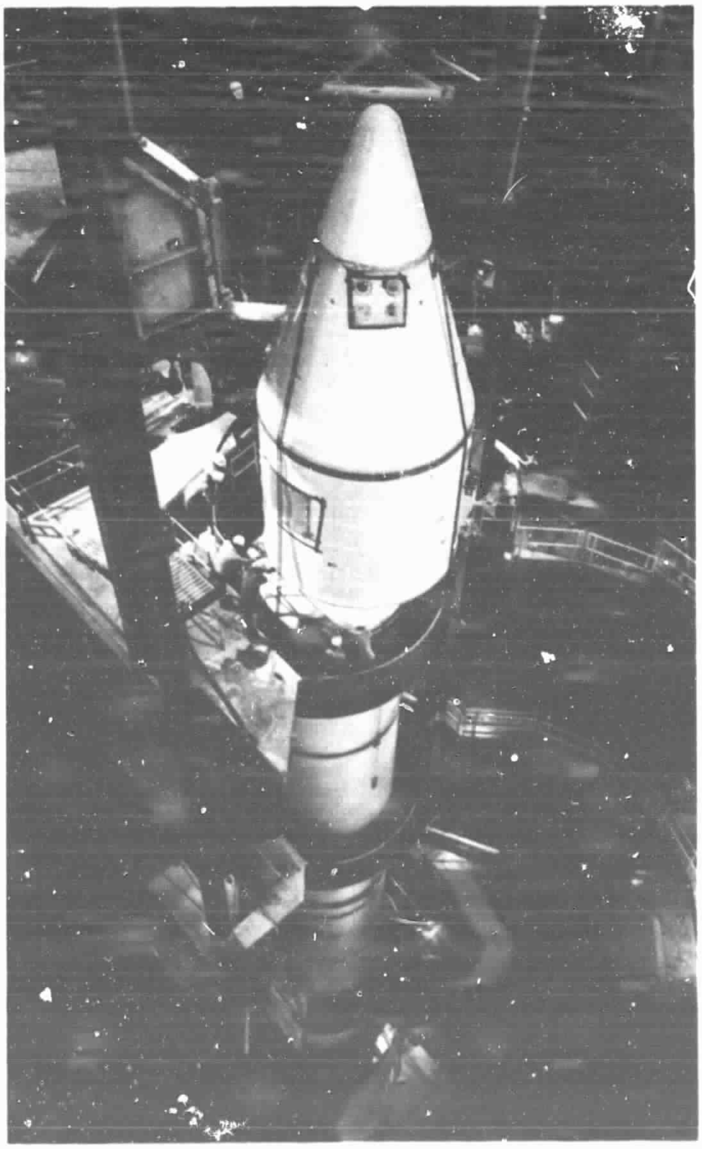
The External Tank is the largest element of the Shuttle. With a total length of about 154 feet and a diameter slightly more than 27 feet, the tank dwarfs many rockets used on manned flights in the past, such as the Titan of the Gemini series. Its rocket-like appearance may lead some to mistake it for the Shuttle's launcher. In reality, it is two tanks linked together by a sleeve called an "intertank." The liquid oxygen tank forms the forward section; the bottom two-thirds is a liquid hydrogen tank. Although the hydrogen tank is the much larger of the two, at launch it weighs only one-fourth as much as its companion because liquid oxygen weighs 16 times more than hydrogen. Together, the 520,000 gallons of propellants and the tank itself weigh a total of 1.63 million pounds.

To maintain the low temperature required for the liquid propellants, the skin of the tank is covered by an inch of foam insulation. Because the External Tank receives and distributes stress loads to and from the Orbiter and the Solid Rocket Boosters attached to it in flight, its aluminum alloy structure has been designed to accommodate complex load conditions. To minimize costs in the non-recoverable tank, its fluid controls and valves were located in the Orbiter.

The External Tank is being designed and manufactured under Marshall's management at the Center's Michoud Assembly Facility, New Orleans, by the Denver Division of Martin Marietta Aerospace.

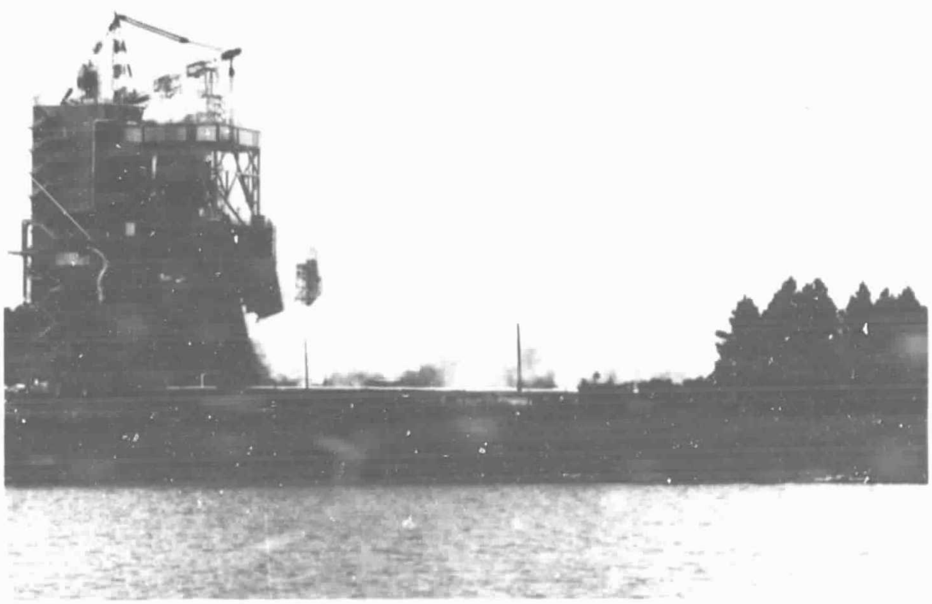
Solid Rocket Booster

The Solid Rocket Booster is the first large solid propellant rocket ever used to boost a manned vehicle. Two of these boosters are used on each Shuttle flight to give the craft the thrust it needs during the early minutes of flight while it is laden with a full propellant load and struggling against maximum gravity.



Unlike liquid rocket engines, which have a complex system of pumps and feedlines, the Solid Rocket Booster's motor is essentially a long cylinder packed with a solid mix of fuel and oxidizer. This cylinder has a hollow center which allows the full length of the motor's propellant to burn at once, unleashing a thrust of almost three million pounds at its peak. The thrust of each motor is almost twice that of the Orbiter's whole complement of three main engines.

While the motor makes up about 127 feet of the booster's almost 150 feet in length, the Solid Rocket Booster has many other important subsystems. The structural subsystem gives the booster the necessary support it needs to serve as the "legs" of the whole Shuttle when the vehicle stands on the pad. It also enables the booster to handle the enormous thrust loads that must be transferred to the tank and Orbiter during flight. The exhaust nozzle on the aft segment of each motor can be moved by as much as eight degrees by the booster's Thrust Vector Control subsystem to help steer the vehicle. Eight separation motors, four housed in the forward compartment and four more mounted in the aft skirt, push the spent boosters away from the remainder of the Shuttle. The recovery system, consisting of parachutes and a homing device, is located in the forward section of the booster and within the nose cap.



The detailed design and integration work on these subsystems was performed by the Marshall Center "in-house." This very active program involved about 280 development and qualification tests at the Center. The subsystem design and integration effort was in addition to the Marshall role as overall project manager for the development of the entire booster, including the motor.

The structural elements of the booster are being manufactured to Marshall design by the McDonnell Douglas Astronautics Corporation of Huntington Beach, California. Thiokol Corporation's Wasatch Division in Brigham City, Utah, developed and produces the motors.

The motor casing, thrust vector control system, structural assembly, and electrical systems of the reusable Solid Rocket Booster were planned for a lifetime of 20 flights; the recovery system was planned for ten.

Shuttle Systems Work

Shuttle Systems Engineering and Analysis is a major Marshall activity that uses the Center's technical competence in the areas of propulsion systems, large launch vehicle structures, and aerodynamics and flight predictions to perform many varied Shuttle tasks. These include those tasks which are a part of the Shuttle projects assigned to the Center.

In addition, Marshall people are working on systems tasks for the total Shuttle vehicle. These efforts include tasks in systems engineering and integration, determination of ground and flight operations requirements, the development and integration of systems common to more than one Shuttle element, and on other special systems tasks assigned to Marshall.

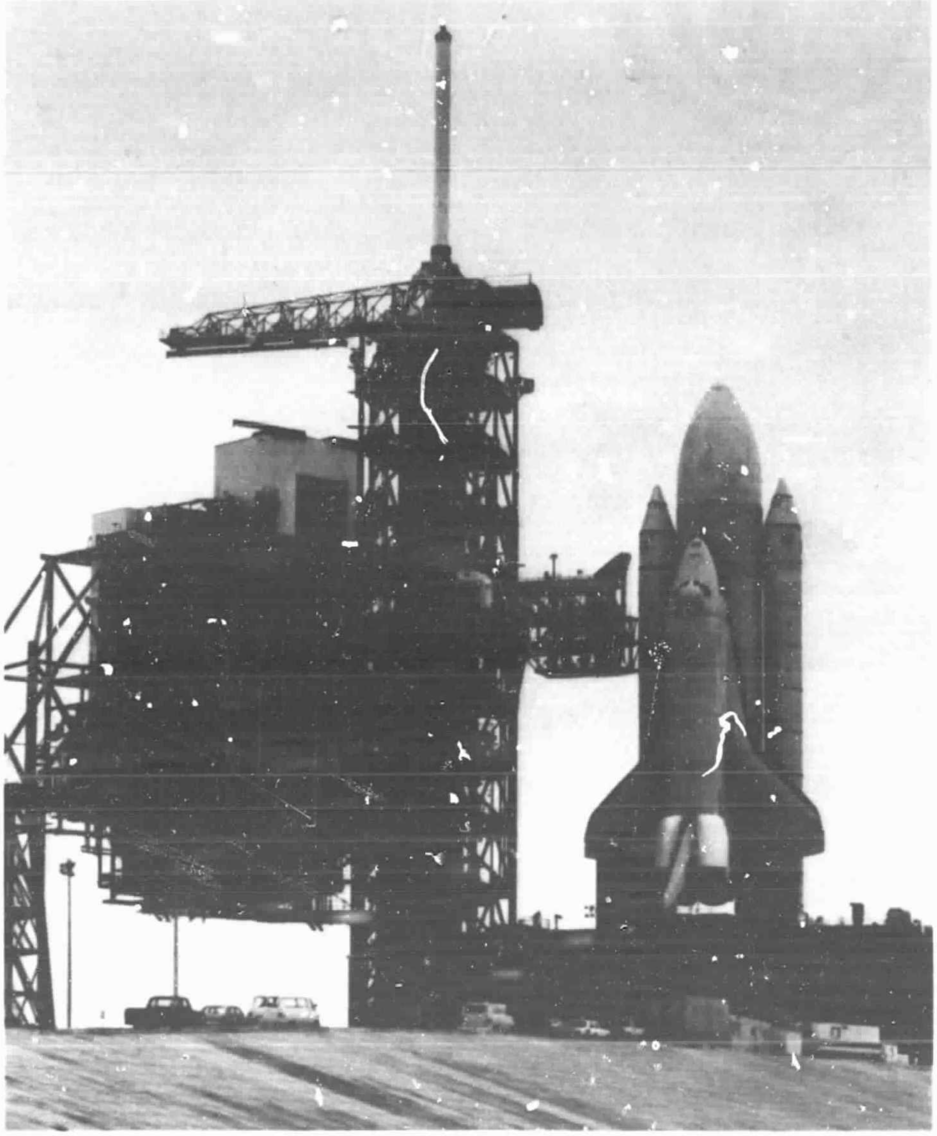
Major Testing

All the major elements of the Shuttle came to the Marshall Center for developmental testing on their way toward space. The External Tank underwent exhaustive structural tests here in various facilities. A former Saturn V moon rocket test-firing stand was converted, at considerable cost savings, to hold the large liquid hydrogen tank for structural testing. The liquid oxygen tank and intertank underwent structural testing in a building used for similar testing of Saturn vehicles. And another facility originally built for testing Saturn I and Saturn IB first stages was converted for use in testing the Solid Rocket Booster's structure.

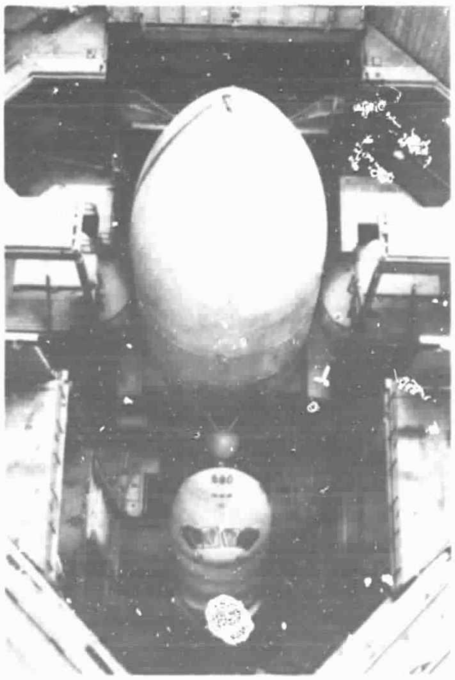
The most spectacular of the Shuttle tests at the Marshall Center was the year-long Mated Vertical Ground Vibration Tests, which took place during 1978 and 1979. For these tests, various Space Shuttle configurations were assembled inside a 400-foot tall dynamics test stand. The information derived allowed Marshall engineers to verify mathematical models used to predict how the Shuttle's control systems and structures would react to the vibrations the spacecraft would encounter during actual flight.

Marshall is also responsible for single engine tests conducted at NASA's National Space Technology Laboratories at Bay St. Louis, Mississippi. The main engine had to be test fired numerous times during its development, and each flight engine must undergo acceptance testing there before it is installed in an operational Orbiter.

Another Marshall Shuttle test responsibility at Bay St. Louis, the Main Propulsion Test, involved test firings using a cluster of three Space Shuttle Main Engines drawing propellants from an actual External Tank. These tests verified the operation of the overall main propulsion system and showed that the separate elements would function properly together.



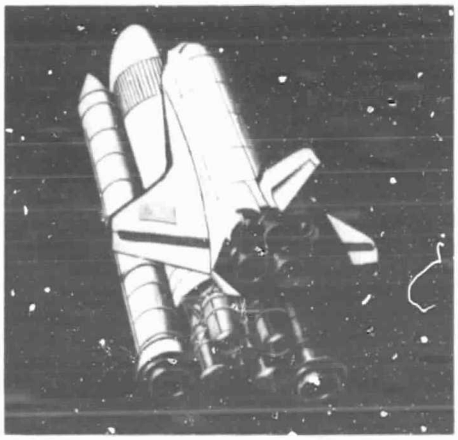
Complete Space Shuttle on the launch pad

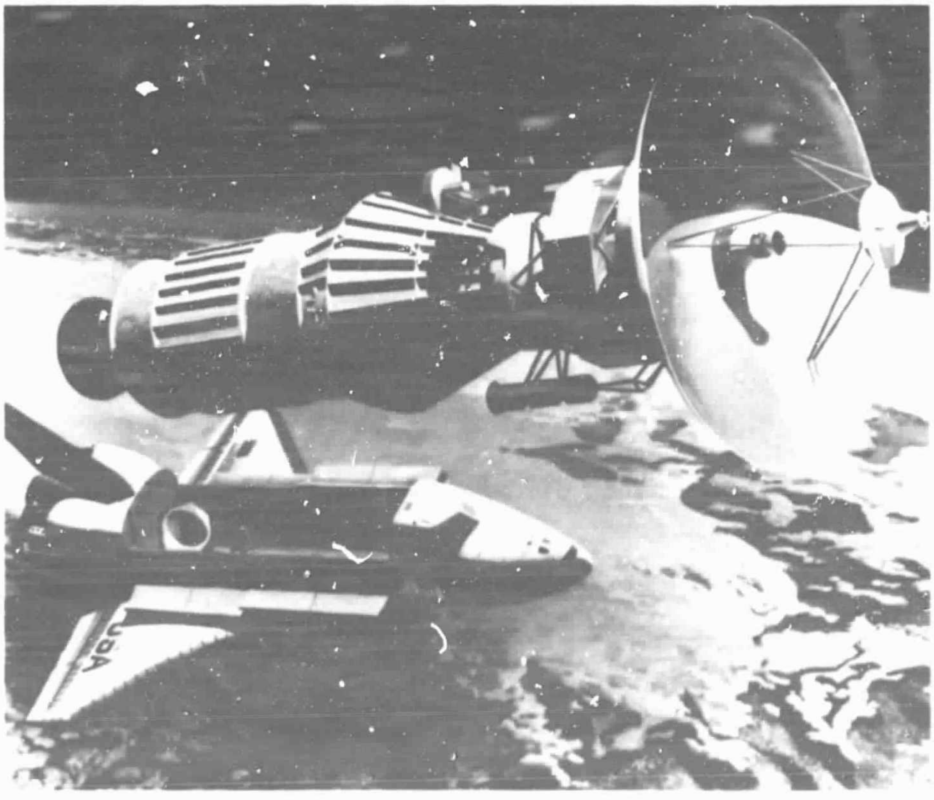


Continuing Shuttle Development

As new requirements are identified, the Shuttle will be modified to meet these demands. Marshall will continue to have responsibility for follow-on development of its propulsion system — the Main Engines, External Tank and Solid Rocket Boosters.

The Center is investigating ways to increase the weight-carrying capability of the Shuttle by adding thrust-augmenting rocket engines beneath the External Tank. This extra "boost module" will be available in the mid-1980s for use on any Shuttle mission that requires more pounds-to-orbit capability.





Inertial Upper Stage

Since the Space Shuttle is a relatively low-orbit vehicle, both NASA and the Department of Defense need a Shuttle "upper stage" to boost certain payloads to high orbit, or to send interplanetary craft out of Earth orbit entirely. To put a satellite into high orbit where it will stay over one spot on the Earth's surface — a communications satellite, for example — it must be placed far above the operating ceiling of the Shuttle. That boost will come from an Inertial Upper Stage.

Prior to launch, this Shuttle upper stage is mated directly to the payload it will boost. That assembly is then loaded into the Shuttle Orbiter payload bay. In an orbit about 150 miles above the Earth, the upper stage with spacecraft attached is deployed and the Orbiter departs. Then, in response to a command programmed into it earlier, the Inertial Upper Stage motor ignites, boosting the spacecraft to a higher orbit or toward another planet.

Because of the variety of its missions and payloads, the Inertial Upper Stage is designed as a flexible system that can be put to use in three different configurations using combinations of two different sizes of solid rocket motors. The Air Force, which has primary responsibility for development of the upper stage, will use the basic two-stage configuration. NASA is also participating in the development and, for its missions, will develop and use two NASA-unique planetary configurations in addition to the basic two-stage system.

As the NASA organization for management and coordination on the Inertial Upper Stage program, Marshall Space Flight Center provides NASA's requirements to the Air Force and participates in contract direction to insure that the operational model satisfies both NASA and other non-Defense user requirements.

Working In Space

One of the Shuttle's most important roles is to serve as both transporter and support platform for Spacelab. This laboratory facility, when placed inside the cargo bay of the Shuttle Orbiter, becomes a versatile orbital research center.

Spacelab is a flexible laboratory, featuring several interchangeable elements that can be put together in various configurations to meet the particular needs of a given flight. A two-section pressurized module provides either a short, or long, habitable workshop for scientists. Five unpressurized pallets can also be placed in the Shuttle cargo bay to hold instruments which require direct exposure to space. As many as eight different combinations of pallets and modules are presently planned.

The first Spacelab mission, one of three being managed by the Marshall Center, will employ the two-section laboratory module and one pallet. The second mission will use three pallets and no workshop module. For such a mission, the science crew will oversee operation of the pallet-mounted experiments from inside the Orbiter's cabin.

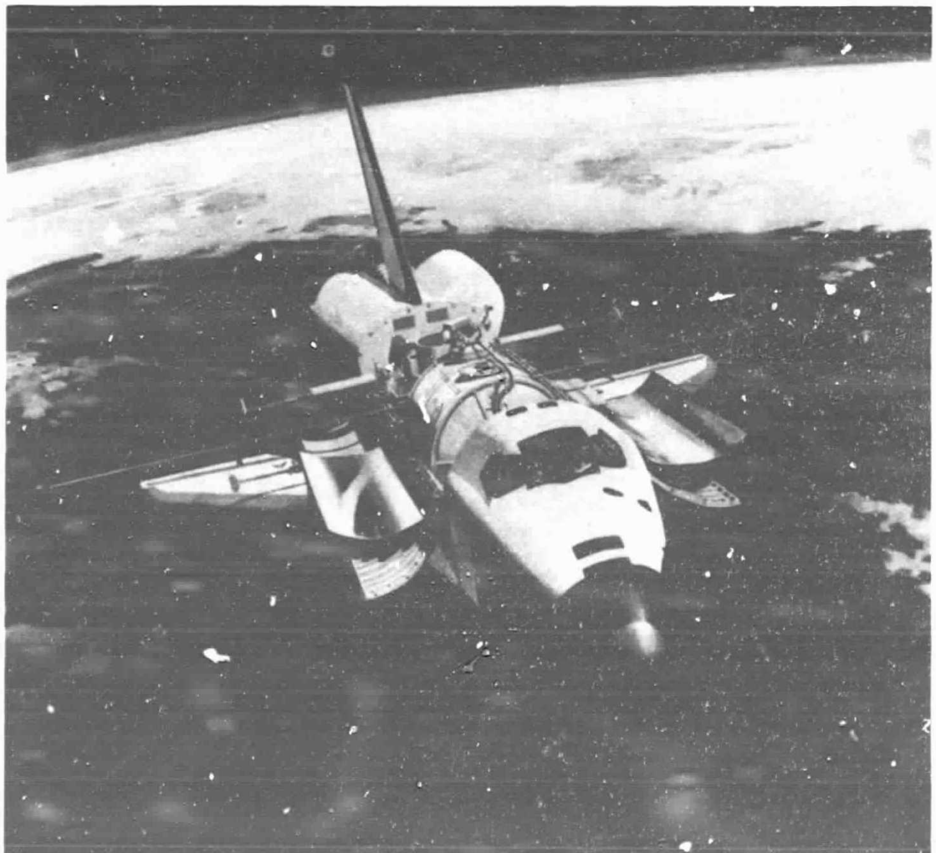
The development of the Spacelab system is being done by the European Space Agency, with NASA's guidance and assistance. The Marshall Center is NASA's lead center for this project and, as such, provides guidance to the European Space Agency and its contractor consortium which is designing and manufacturing the equipment to be furnished to NASA. It is also directly responsible for development of certain related equipment, such as the tunnel through which crew members will transfer to the Spacelab from Shuttle living quarters.

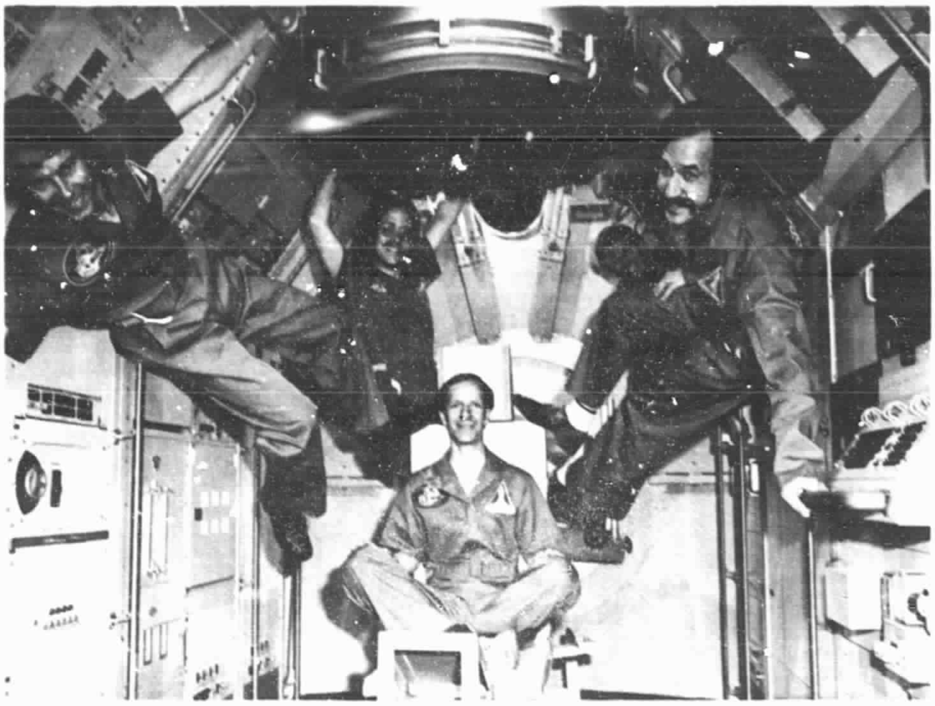
Spacelab Mission Management

As indicated earlier, the Marshall Center has another role in Spacelab that is quite apart from the development of the facility itself. The Center's Spacelab Payload Project Office is the focal point for planning and directing the actual Spacelab missions.

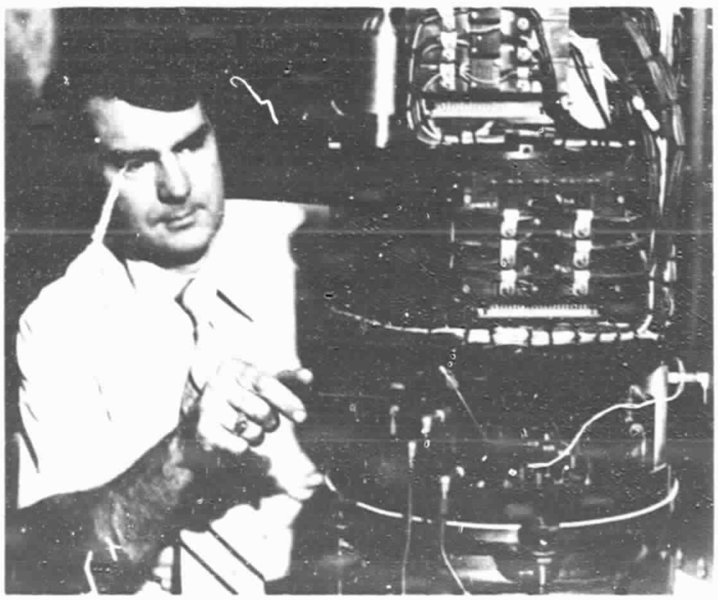
Preparations for the first three Spacelab flights are already well underway. These pace-setting missions will fly in the early 1980s.

Preparing for a mission is a complex task. In some cases, Marshall's people manage the development of an experiment to be flown aboard Spacelab. In others, they guide non-NASA users in the definition, design, and preparation of their own experiments. The Center also develops requirements for mating the finished experiment to Spacelab-provided equipment, such as racks, pallets and the data management system, and for checking out each piece to make sure it will work both independently and as an integrated part of the whole Spacelab payload.





Payload Specialists for Spacelab 1 (left to right): Dr. Ulf Merbold of West Germany, Dr. Michael Lampton of the U.S., Dr. Claude Nicollier of Switzerland, Dr. Byron Lichtenberg of the U.S., and Dr. Wubbo Ockels of the Netherlands.



One of the most unique features of Spacelab is that it affords scientists the opportunity to actually go into orbit to operate their own experiments, or select some specialist to do this for them. In the past, scientific investigators had to rely on NASA's astronauts to operate their experiment equipment. The people selected to do this work on Shuttle flights are called *payload specialists.* Their extensive training is another of the Marshall Center's responsibilities as mission manager.

The payload specialists for the first two Spacelab missions have been in training for some time. Because the first mission is a joint mission sponsored by both NASA and the European Space Agency, the payload specialists for that flight will include a European — the first to fly in space from another free-world country. In training for this flight are five payload specialists: two Americans and three Europeans. Two will be identified to fly aboard Spacelab, the other three will operate ground-based experiment equipment and assist the pair in orbit.

The Spacelab 2 payload crew consists of four Americans, including a woman. Two will go into space and two will operate from the ground.

As plans are made for future Spacelab flights, the Marshall Center is expected to remain a major participant in mission management.

Experiment Preparation

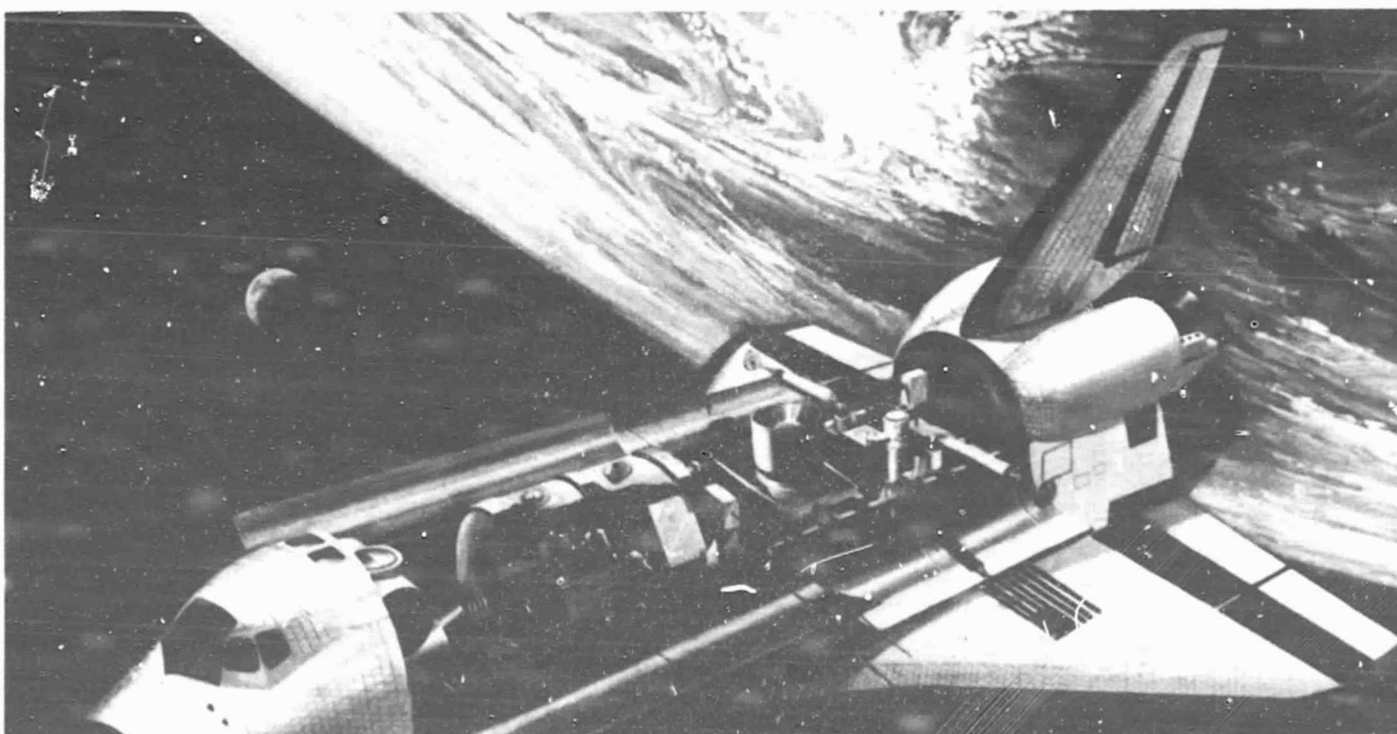
In recent years, an increasing amount of the Center's effort has been devoted to the development of experiments to be flown in space aboard Shuttle and Spacelab. In this role, Marshall's own scientists often become "customers" for the Center's mission management service just described.

During the 1970s highly-respected "cells of excellence" were developed within the Center in many of the space-related sciences. Leaders in these disciplines are now preparing for flight opportunities for their experiments — over 30 such projects are now under way at the Center. These projects are assigned to many organizations of the Center, with the heaviest concentration being in the Space Sciences Laboratory.

One major area where the Shuttle and Spacelab are used for extensive experimentation is in the study of the effects of gravity on processes essential to the production of important materials used on the Earth. This work, which was initiated on Apollo, Skylab and sounding rocket flights, is a Marshall Center specialty aimed at exploring the fundamental characteristics of material behavior and investigating how various materials interact during their formation.

The primary benefit of this work is expected to be in the application of space experiment-derived knowledge to the Earth-based production of such things as optics, composite materials used in weight-critical products, electronics crystals and pharmaceuticals. But there is a strong possibility that this work may also result in the production in space of some unique products with small volume market demands and high commercial value.

The experiments now underway cover an extremely wide variety of materials and processes. Examples include investigations into the growth of high performance crystals and semiconductors, the formation of unique alloys and composites, the precise separation of biological substances such as enzymes, the formation of unique glasses, the preparation of very pure materials through the use of containerless processing and ultra-high vacuum processing techniques, and the preparation of unique chemicals.

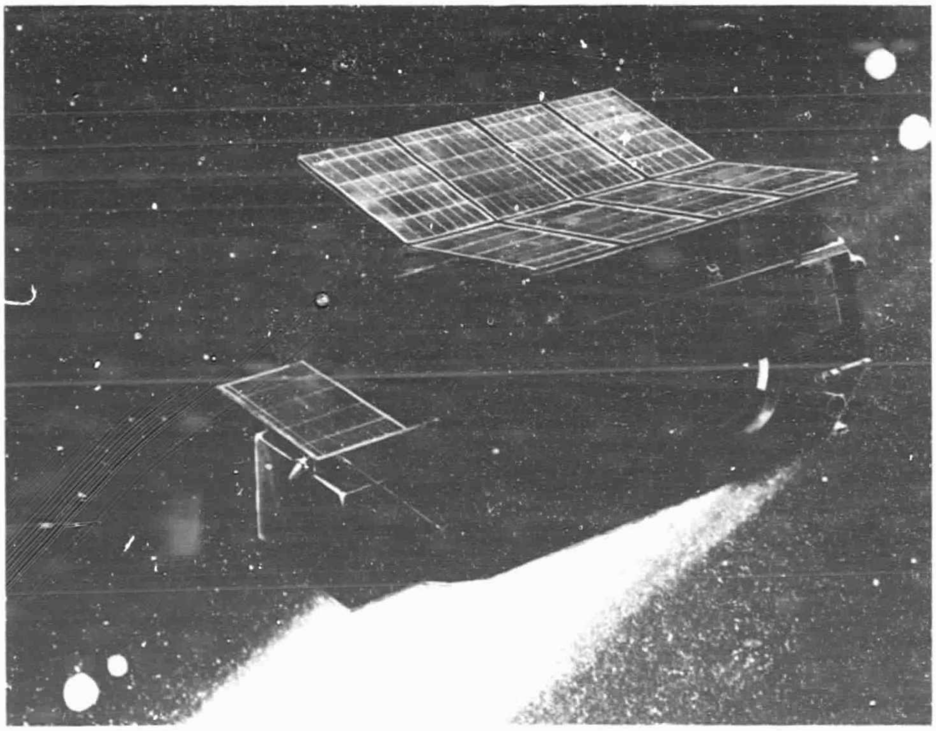


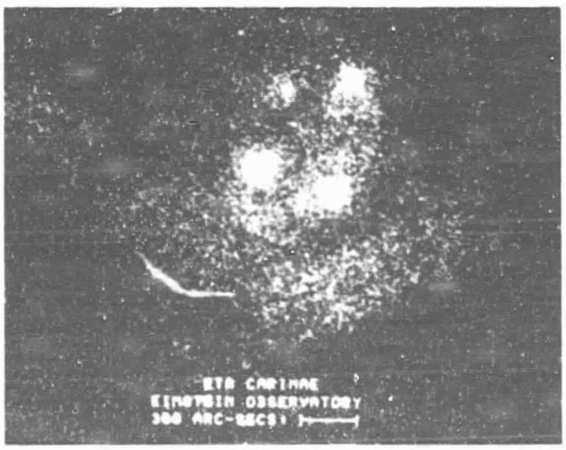
Studying the Stars

The science of astronomy deals with the most fundamental issues that face reasoning man: how did my world come into being, what is the order of the universe, and what role does my world play; what lies ahead for me and my descendants?

Answering these questions is the astronomer's challenge. He seeks to learn and understand the laws governing the structure and evolution of his universe by observation and interpretation. Yet, the scale of distances to even the nearby stars is so great as to prevent modern man from visiting them for study. The astronomer can only be an observer — not an experimenter. He can learn only from observing what nature is doing.

Never before have astronomers had such capabilities to observe as can now be provided through the use of spacecraft. High above the Earth's blanket of obscuring atmosphere, astronomical observatories like those being developed and flown by the Marshall Center can now give astronomers a new look at the heavens.





High Energy Astronomy Observatory

Marshall's three-mission High Energy Astronomy Observatory project has given astronomers new means of studying some of the most intriguing mysteries of the universe: pulsars, quasars, exploding galaxies, and black holes in space.

The high energy rays produced by such sources cannot be studied through Earth-based telescopes because of the obscuring effects of our atmosphere. They were observed initially by instruments on sounding rockets and balloons, and by small satellites. Greatly improved capabilities were built into the three spacecraft of the High Energy Astronomy Observatory series.

The first was launched in 1977. During its extended 17 months in space, it mapped the X-ray sources in the heavens. The second satellite provided the earliest spacecraft-generated X-ray images of selected "wide" objects, such as galaxies and nebulae. The role of the third mission is to collect celestial gamma ray and cosmic ray data.

Some other achievements of this series thus far are: the discovery of a universal hot plasma constituting a major fraction of the mass of the universe; the location of a new black hole candidate that brings the total known to four; the expansion of the list of the known X-ray sources from 350 to nearly 1,500; and the production of the first spacecraft-generated X-ray images of celestial objects other than our own sun.

As participating scientists continue to sift through the enormous volume of information provided by these observatories, this list is expected to grow tremendously.

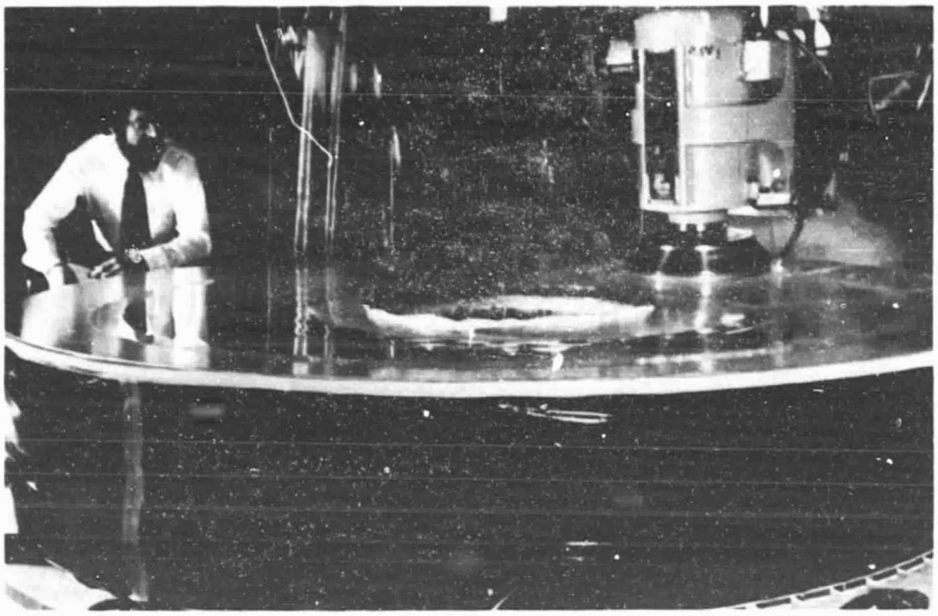
Space Telescope

The science of astronomy makes use of many types of observations, from low-energy radio waves through the ultra-high energy gamma rays, but most scientists still believe that the greatest supplier of astronomy information is the optical telescope that brings in the ultraviolet and infrared parts of the spectrum as well as light that can be seen by man. Again, however, the conditions of working in the Earth's gravity and through the turbulence and absorbing power of the Earth's atmosphere impose practical restrictions on all but a few types of observations.

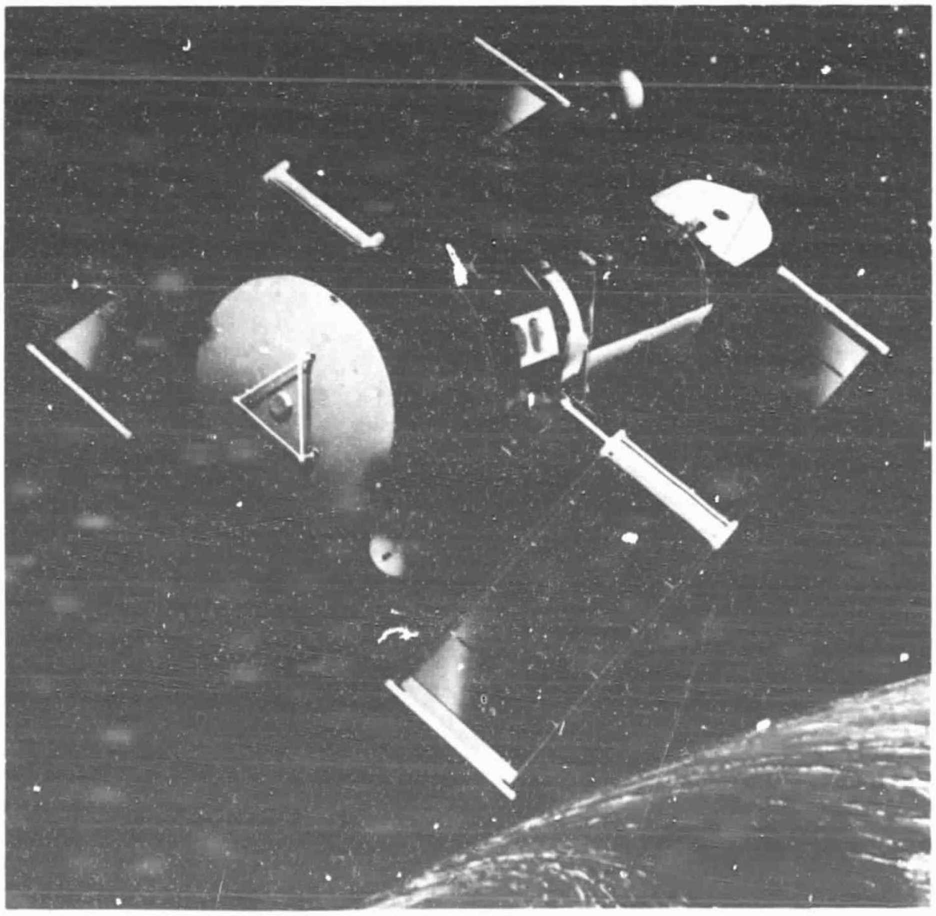
This means that the only practical successor to existing Earth-based telescopes is a high-quality telescope in space.

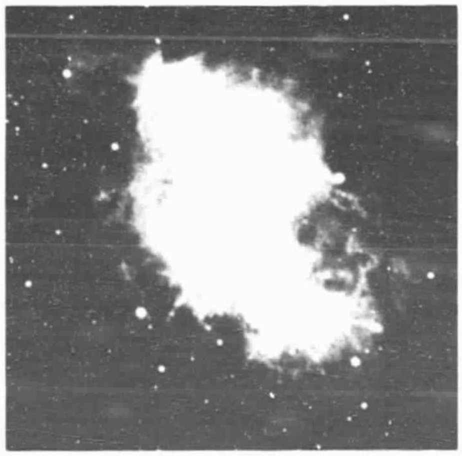
Marshall's Space Telescope project will provide a 2.4 meter optical telescope that will revolutionize astronomy. The Space Telescope will enable astronomers to see seven times deeper into space than is now possible with the finest Earth-based instruments. It will expand the volume of space open to inspection by 350 times. This superb system will fully exploit the advantages of space observation. Many astronomers believe that this natural step in the evolution of astronomy will be viewed by history as ranking with the establishment of the Copernican concept of the universe 500 years ago.

The Shuttle will launch the Space Telescope into Earth orbit in the mid-1980s. Once in orbit, the Space Telescope will be deployed as a free-flying satellite, operated by an independent Space Telescope Science Institute under contract to NASA.



The telescope's primary mirror being ground





Using Space to Benefit Earth

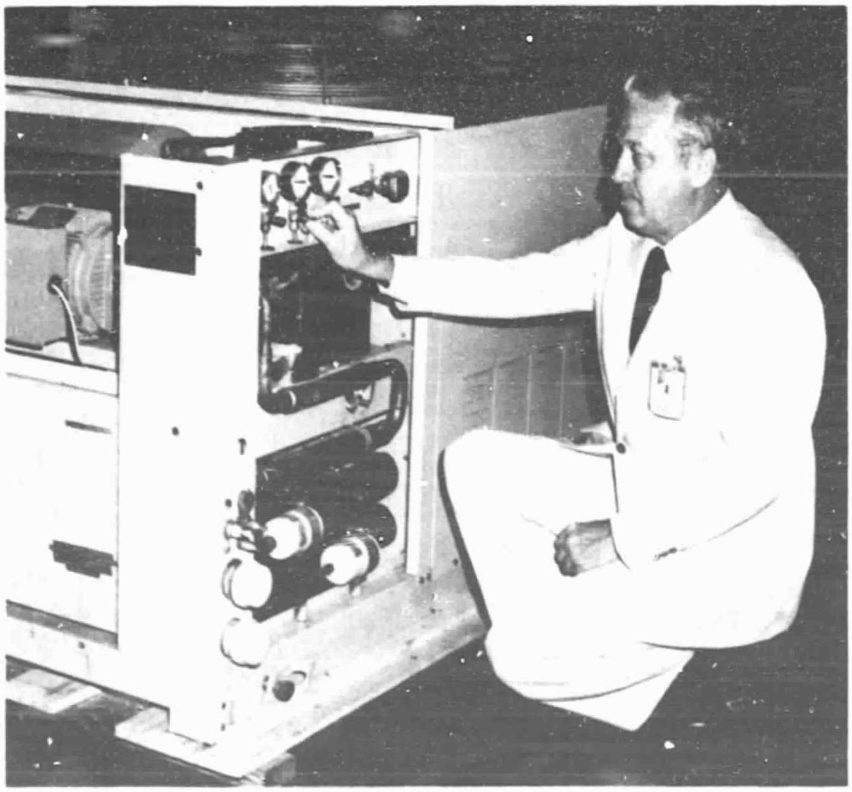
The knowledge and skills gained from pioneering efforts in the initial exploration and use of space is now paying off in some unexpected ways. Increasingly, Marshall's space expertise is being applied to the non-space sector as well.

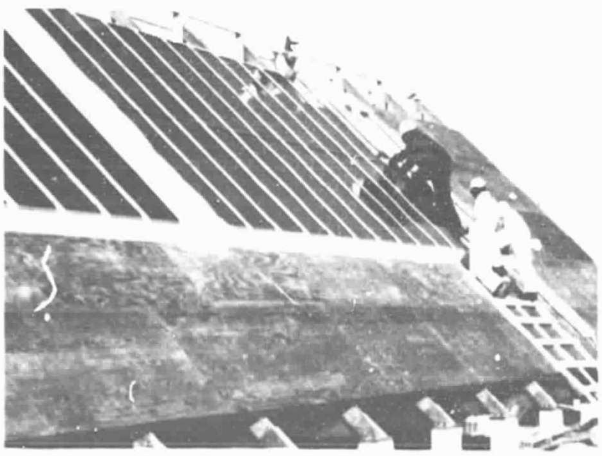
Solar Energy Projects

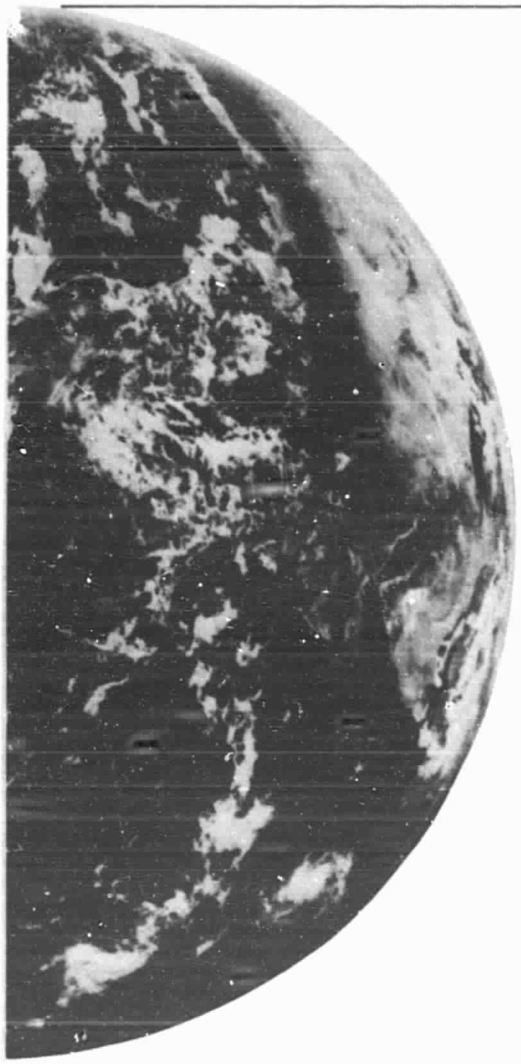
One of the best examples of this is the Center's participation in the National Solar Heating and Cooling Program and the Solar Demonstrations Applied to Federal Buildings Program, both directed by the Department of Energy.

The first of these two programs, the National Solar Heating and Cooling Program, is itself a two-pronged effort. One objective is to develop new types of systems; the other to demonstrate existing commercially available hardware. Under these programs, the Marshall Center is managing the installation and evaluation of solar energy systems in schools, homes, hospitals, office buildings, hotels and a national park welcome center.

Marshall engineers are also providing technical management of a multi-million dollar program to stimulate the use of solar energy to





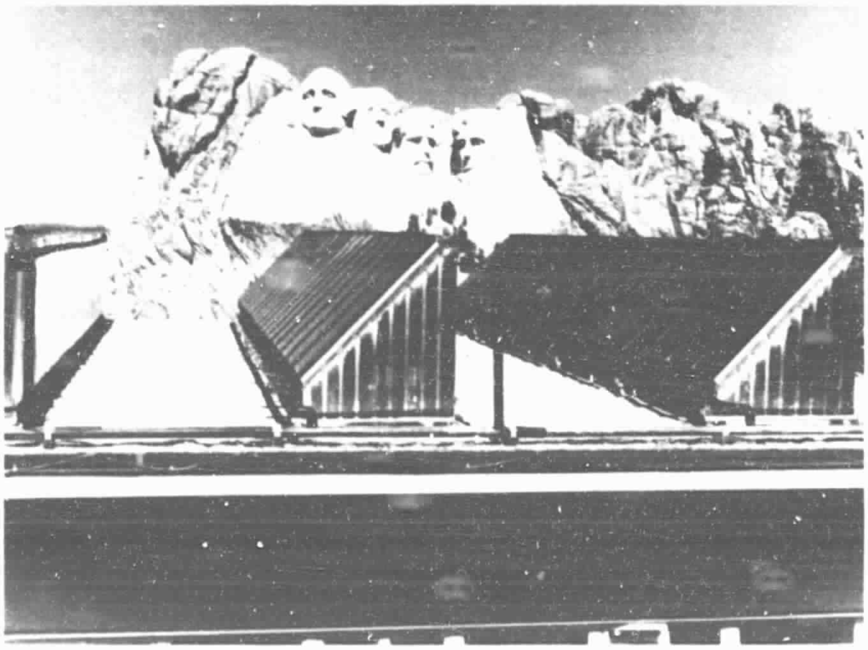


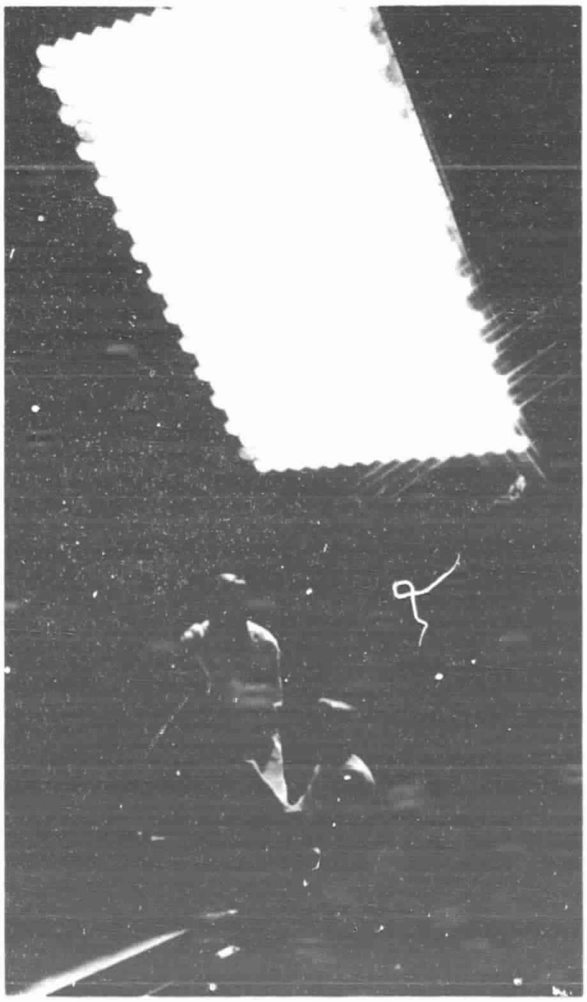
heat and cool federal buildings. This program is designed to demonstrate to the public the government's confidence in solar energy as a viable energy source by installing off-the-shelf solar equipment in federal buildings.

The Center is well equipped for this solar energy role. Its large outdoor test facility provides an outstanding means for testing and evaluating solar energy systems and components in varying combinations. In addition to outdoor testing, tests are also conducted indoors under controlled conditions with a solar simulator, a very large lamp array that provides the "continuous sunshine" necessary to permit comparison of collector performance.

As part of the Solar Heating and Cooling program, the Marshall Center is managing a joint government and industry effort to speed development and establishment of a rating, certification, and labeling standard for solar collectors. The end result will be a catalog of solar collector ratings to aid the consumer in selecting the right system for his or her particular need.

All of these programs, of course, draw on the experience Marshall's people have gained through years of developing solar energy systems and thermal control measures for spacecraft.





Mineral Extraction

In another interesting venture, the Marshall Center is applying technology developed for space use to help remedy one aspect of the nation's energy shortage by making coal mining safer, more productive and more economical.

The Center is working with the Department of Energy to apply an automated guidance and control system to a longwall shearing machine, used to grind coal from the seam. Sensors will locate the seam edge and digital electronic controls will direct the machine's cut, allowing the machine to mine coal faster, yielding more coal per seam, and reducing cutter wear by preventing the machine from mining into adjacent rock and dirt. The techniques being applied to this project are adapted from those used earlier to develop the guidance and control system for the Lunar Roving Vehicle.

Sharing the Gains

Solutions to everyday problems here on Earth are often discovered in the process of solving problems for space systems. Marshall is aggressive in communicating these new developments to American industry and the public. A small, full-time staff is dedicated to making this kind of technology known and available.

In an average year, these people will publish about 150 detailed reports on new technology developed at the Marshall Center. Recently, these reports have ranged from a computer program for body fluid analysis, to a lightweight, portable firefighting module.

Two developments that have gained much national attention recently are a Power Factor Controller and an Image Enhancement Process. The power device is simple and can be put together by even a knowledgeable hobbyist with parts bought at any electronics store. It cuts the electrical consumption of motors to which it is attached by as much as 70 percent! It does this by

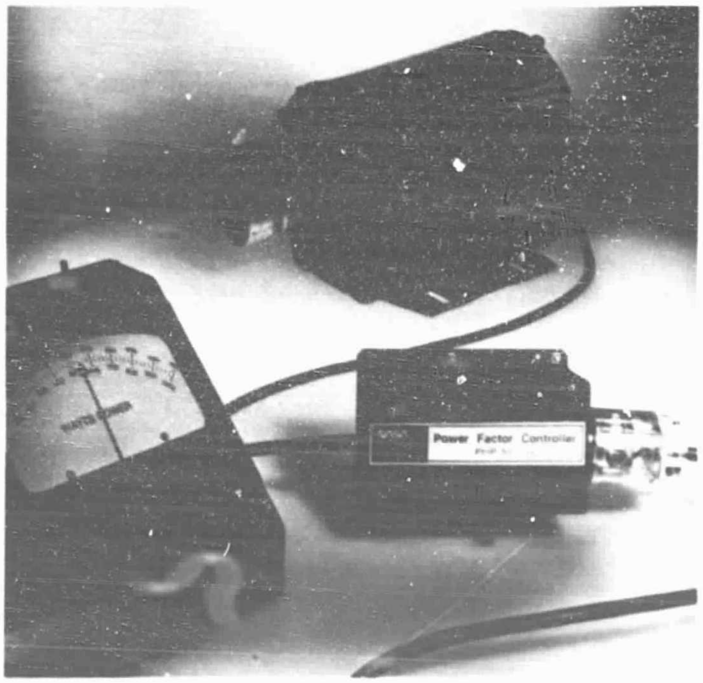
automatically providing only as much voltage as the motor needs to do its work. Power that would normally be wasted as heat from the motor is saved. Many private companies have already been licensed to manufacture and sell these small devices. Soon, they will be an important part of home appliances.

The Image Enhancement Process was discovered by a Marshall chemist who had been asked to find a way to salvage underexposed astronomy films. She found that she could irradiate the apparently blank film with a harmless level of radiation, then sandwich it together with another piece of unexposed film. Traces of silver in the original, too faint to be seen, would then cause a stronger image on the second film. A normal print can be made from this new negative. The process was found to work as well with old, badly faded photographs. The inventor has shown that the process can be used to restore early historical photographs.

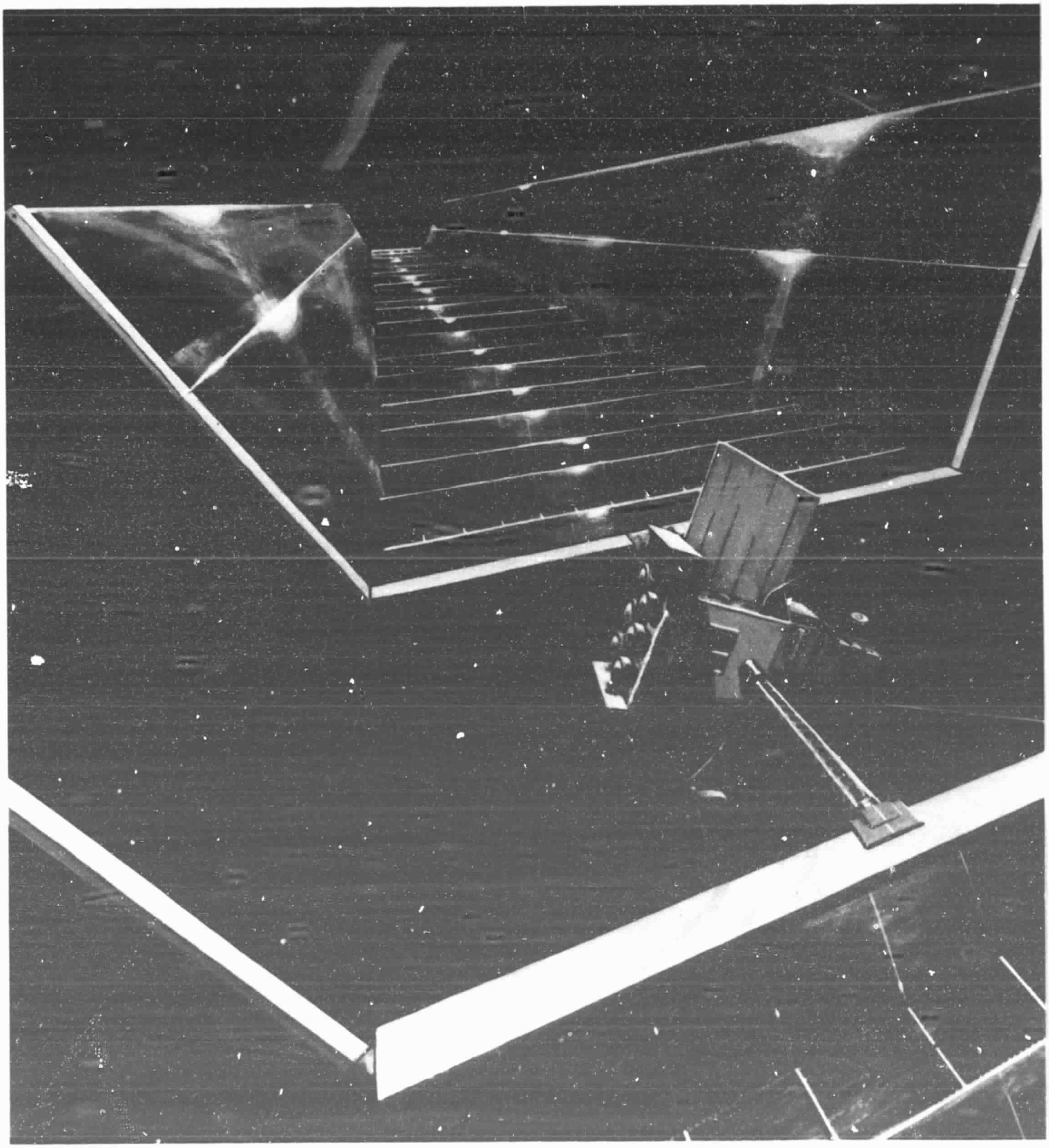
The process has since been found to offer great possibilities in the medical and dental X-ray field. The dosage of X-rays used for diagnosis can be cut by as much as 90 percent and the films later enhanced to show normal detail.

Chemist Barbara Askins of the Marshall Center [illegible] Inventor of the Year [illegible] enhancement process.

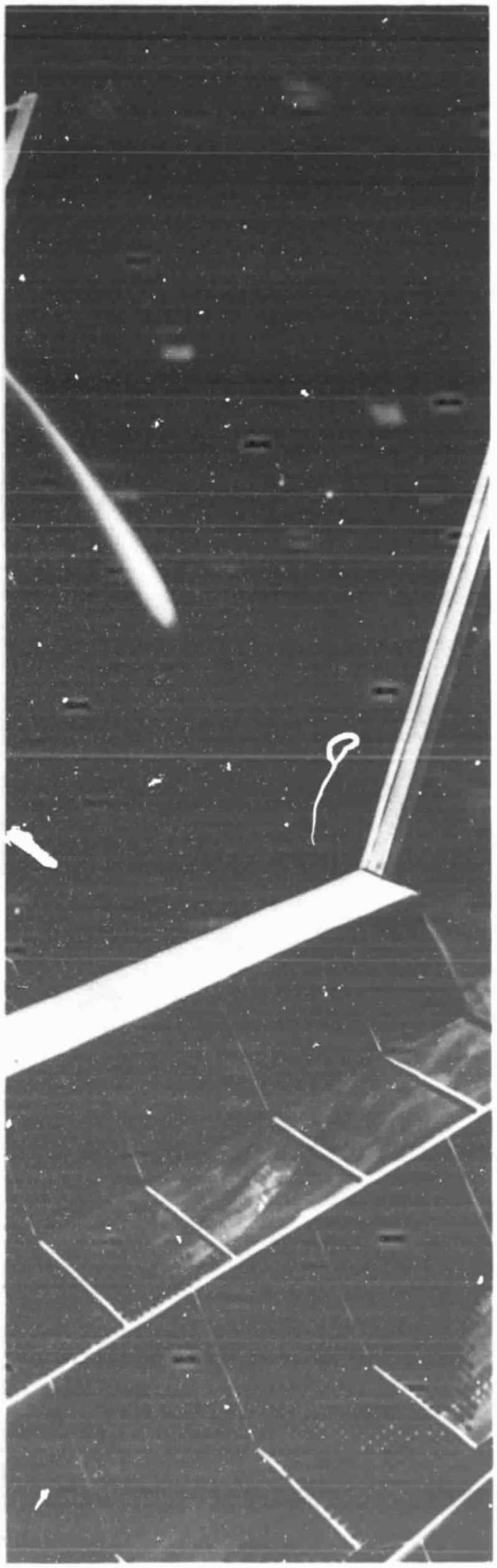
[illegible]



PROBING THE FUT



URE

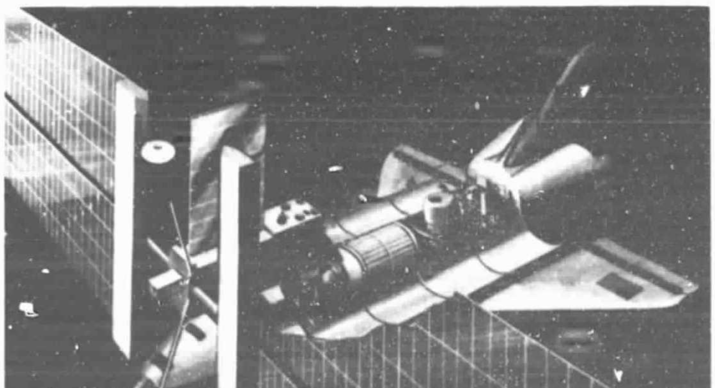


Through their involvement in the development of the agency's long-range plans, Center planners have contributed, and continue to contribute, to NASA's overall objectives by focusing on those areas where Marshall has special capability. Within Marshall and NASA, the overriding considerations in advanced program planning are to fulfill national needs, make maximum use of existing space systems, and to advance the nation's capabilities and objectives in a step-by-step, logical manner.

Power Systems

Perhaps the key system that demonstrates this philosophy is the 25-Kilowatt Power System. The power system will be a free-flying solar power source which, when docked to the Shuttle Orbiter, can provide it and an onboard Spacelab with power that gives them extended mission duration capability. The power system will also provide attitude control and stabilization, as well as additional heat rejection capability for the Orbiter and whatever payload is aboard. These augmentations will increase individual mission durations from the current 7-12 days to 60-90 days and, at the same time, provide a major increase in the power available to operate onboard experiments.

The power system will also work in a free-flying payload mode. Experiments or spacecraft can be left attached to the system in space while the Orbiter returns to Earth. This mode is extremely attractive to a large number of users, particularly those whose instruments require long flight duration and need high levels of power. The power system uses a new concept in solar energy collectors, a concept that is also a key part of the Solar Electric Propulsion System which is discussed later.



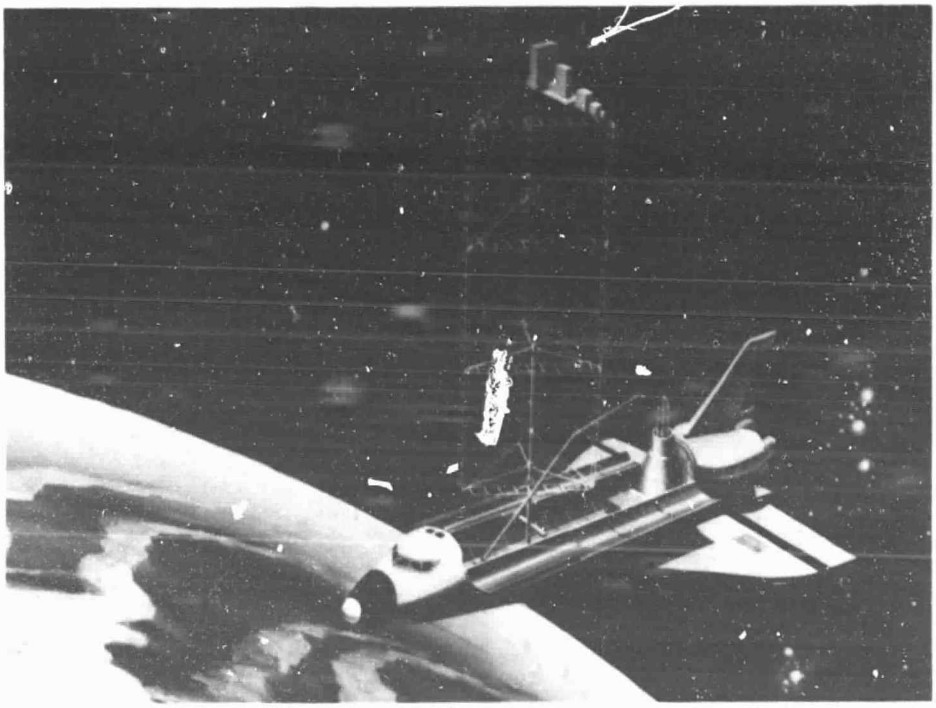
Building in Space

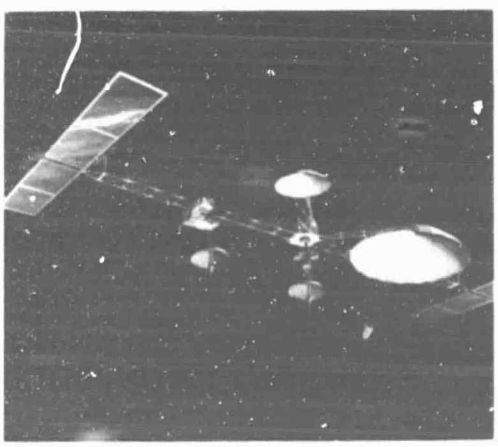
Another concept being pursued by Marshall which may prove to be a simple and cost-effective solution to achieving long-term flight, involves the use of an orbiting space platform on which science and applications instruments can be mounted. Power, telemetry, stabilization, and other support services would be provided to each of these attached payloads by the platform's own power system. Effort is concentrated now on small, simple platform concepts, but a number of more sophisticated platform concepts, like those for a geostationary communications platform or a multi-discipline platform, have been examined.

In order to provide the capabilities necessary to construct and maintain such platforms and other large space systems, a large structures study activity has been underway for some time. This activity has three areas of effort: definition studies of various modes of construction for deployable structures such as antennas; development and testing of a ground demonstration model of an automated beam builder which makes triangular truss beams from rolls of thin aluminum stock, and simulations of various assembly and joining techniques in a unique underwater Neutral Buoyancy Simulator.

These large structures, platforms, and power systems activities are complementary and, when coupled with the Marshall Center's experience on Spacelab and in Spacelab payload planning and integration, they form a solid foundation for planning near-term utilization and augmentation of NASA's Shuttle-based transportation system.

The capability to build large structures in space may be demonstrated in the 1980s





Planning for Science

There are, however, other areas of planning which are equally important. One of these is the preparation of science and applications payloads.

The Advanced X-ray Astrophysics Facility is a good example. It is viewed as the next step in X-ray astronomy after the High Energy Astronomy Observatory series. This new facility will extend current X-ray surveys to greater distances and will allow the study of presently known sources in greater detail and resolution.

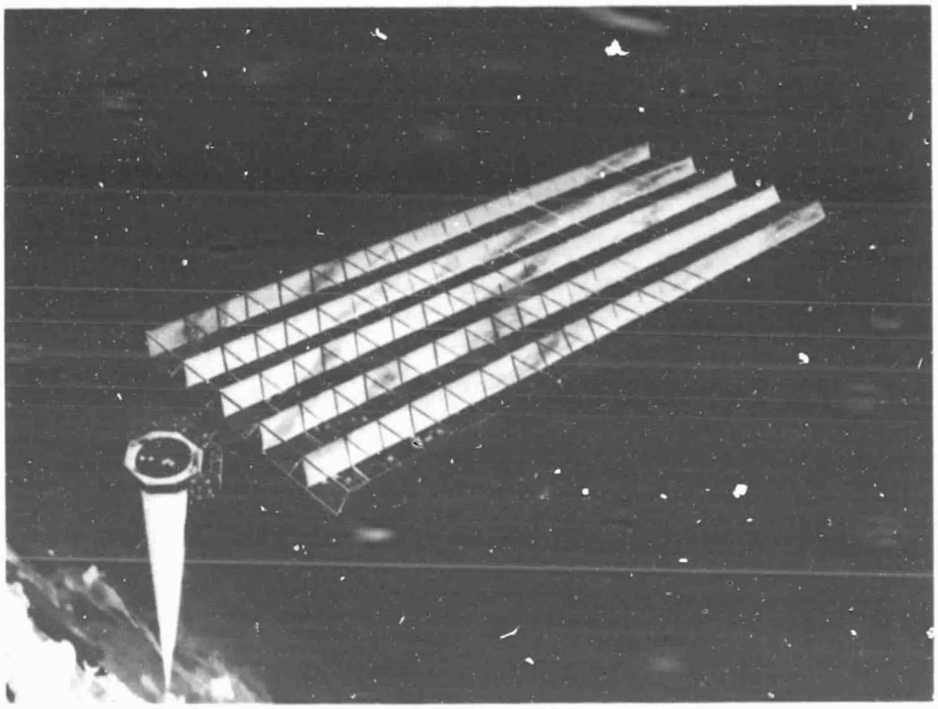
Another very challenging project with which the Marshall Space Flight Center has been involved for some time is the Gravity Probe B. A scientific research and testing program is underway to develop an ultra-precision cryogenic gyroscope capable of testing specific predictions of Einstein's General Theory of Relativity. Recent observations made with the High Energy Astronomy Observatory spacecraft have increased the scientific community's interest in establishing a gravitational theory that will best describe various phenomena in our physical universe including pulsars, quasars, and black holes. Gravity Probe B would help to do that.

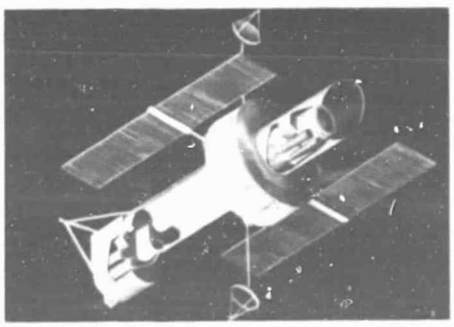
In addition to these science payloads, Marshall is studying several advanced space materials processing payloads including a Space Vacuum Research Facility and a Materials Experiment Carrier. These payloads would utilize the unique properties of space-microgravity and vacuum to accomplish varied materials research to help private industry develop unique and better pharmaceuticals, alloys, biologicals, and other products for terrestrial use.

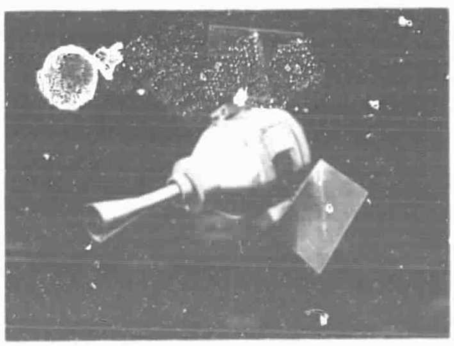
In Search of New Energy

National problems in energy have highlighted the need for major advances in the nation's ability to develop alternate energy sources at acceptable costs and with minimum effect on the environment. To meet this need, the Marshall Center has been working within NASA, with the Department of Energy, and with other government agencies to define alternative energy programs that would take advantage of the technology of the space program.

One potential solution to easing the world's increasing demand for electrical energy is the Satellite Power System. The Marshall Center is now studying the feasibility and definition of this concept, which would use a satellite with a very large blanket of solar cells to convert solar energy directly into electrical energy via the photovoltaic method.



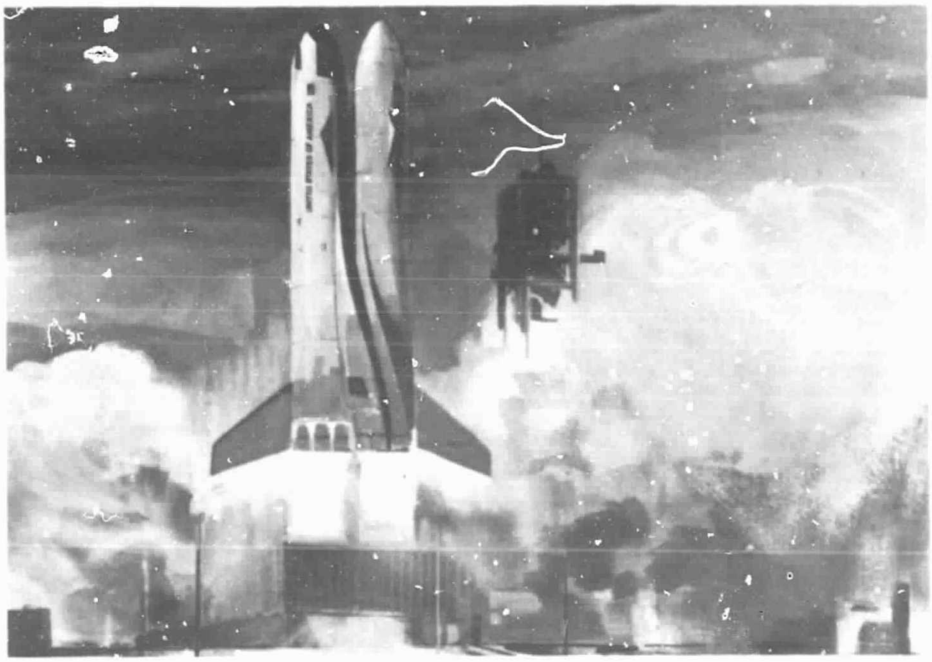


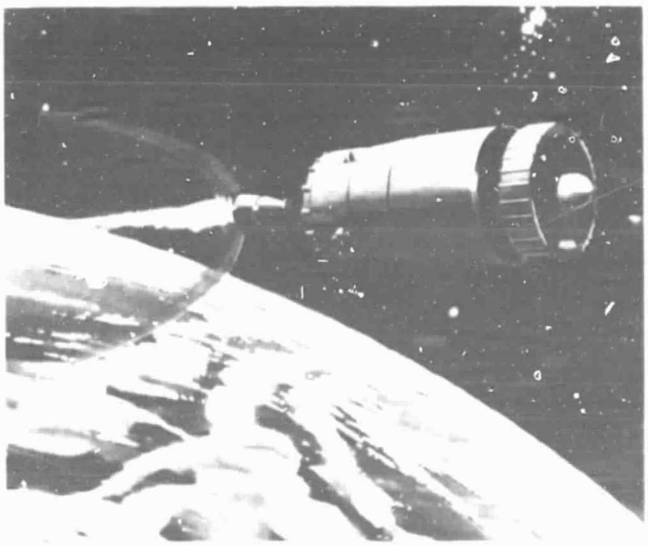


This electrical energy would then be converted into microwaves and beamed from an antenna on the power satellite to a receiver-antenna, called a rectenna, on the ground where it would be reconverted to electrical energy and fed into utility power lines.

The near-term phase of this project involves a number of technology and engineering activities, as well as ground and space experiments or demonstrations to investigate critical areas. The technical feasibility and environmental impacts of the microwave system have to be determined, and the problems of making energy conversion devices and building such large structures are being assessed. This energy source offers great promise as one of the future steps toward diminishing the rapid depletion of the world's fossil fuel supply.

Although the safe management of nuclear waste generated by nuclear power plants and nuclear weapons production does not fall in the category of alternate energy sources, it is an area of vital importance to the continued or increased use of nuclear power in this nation. In concert with the Department of Energy, the Marshall Center is assessing the desirability of disposing of certain high-level nuclear wastes in space as an augmentation of the currently planned national nuclear waste management program. Various space disposal concepts have been considered, including solar system escape, injection into the Sun, placement on the Moon, and injection into a stable solar orbit. The currently favored concept is injection into a circular solar orbit about halfway between Earth and Venus. Orbital calculations indicate that this orbit is stable for at least a million years.





New Vehicle Concepts

Studies are also underway at the Marshall Space Flight Center on the special transportation requirements of the Satellite Power System and other missions of such an era. Concepts being investigated include those for new heavy lift launch vehicles and Shuttle improvement or growth options, such as replacing the Solid Rocket Booster with reusable liquid boosters. These could increase the Shuttle's payload weight-to-orbit capability by approximately 50 percent. Another option could be used when payload return-to-Earth capability is not required. The Shuttle Orbiter might be replaced by a special cargo carrier to accommodate larger or heavier payloads than the Orbiter is capable of handling. Launch facilities, with moderate modifications, would be capable of handling any of these one-way vehicles.

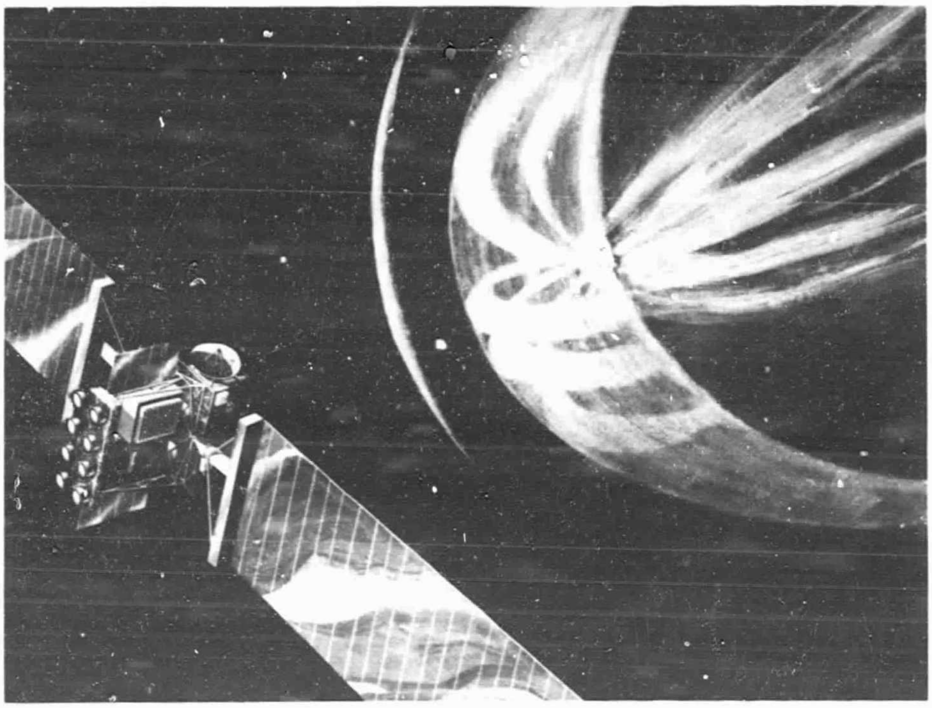
Another class of spacecraft known as the Orbital Transfer Vehicle is required to move cargo and people between low Earth orbit where the Shuttle operates and geosynchronous orbit. Such vehicles are also needed to place payloads on planetary trajectories. These vehicles will offer important features not

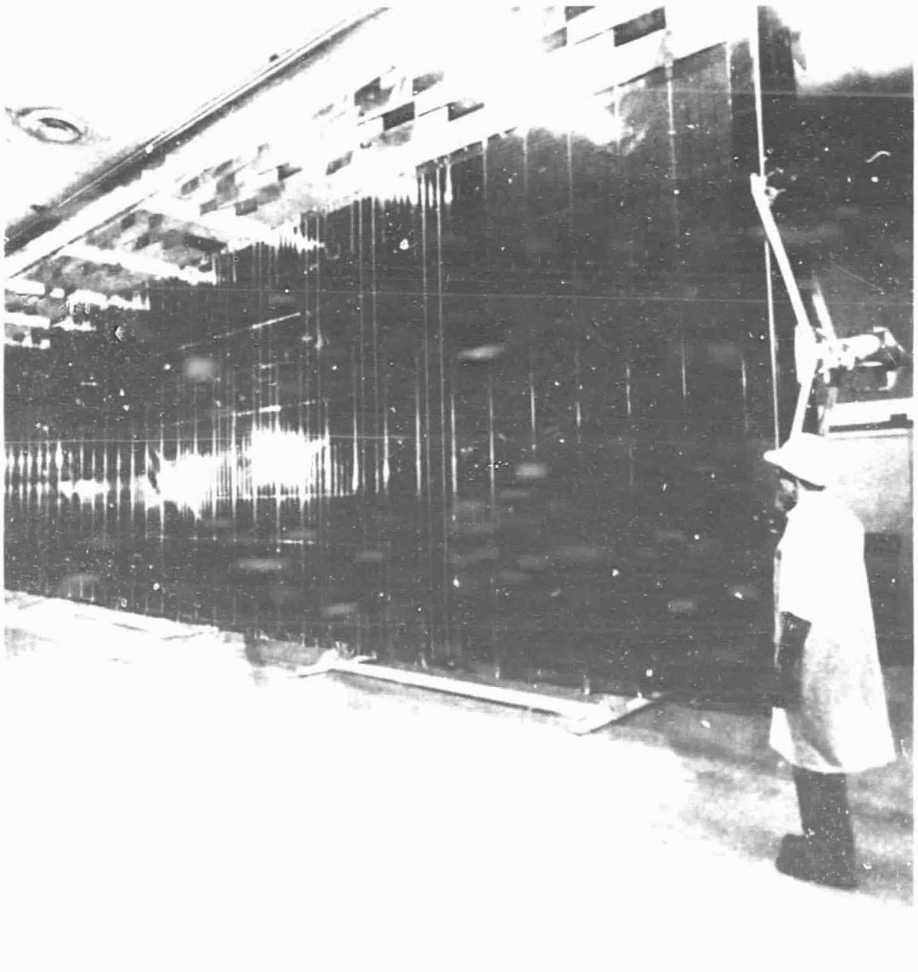
available with the Inertial Upper Stage described earlier: reusability, greater payload capability, and the ability to carry astronauts. A broad spectrum of transfer vehicle concepts are being studied in an attempt to identify the system that will best meet the nation's future delivery requirements.

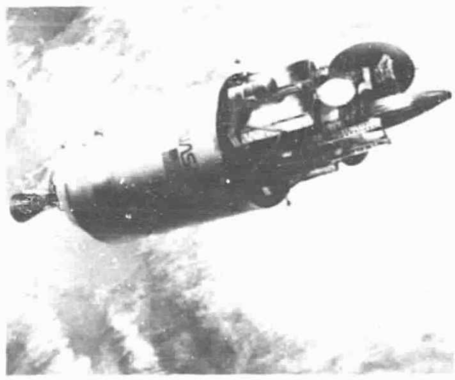
Many vehicles of the future will use solar electric propulsion. Electric propulsion systems, which generate thrust by passing mercury ions through an electrostatic field, have been under study for many years.

Based on seven years of concept definition and applications studies, the Marshall concept of a standard Solar Electric Propulsion System has emerged as a cost-effective approach to accomplishing the wide variety of missions that require the high efficiency, low thrust capabilities peculiar to electric propulsion.

The technology needed to build a large deployable solar array for the solar electric stage was developed as part of Marshall's electric propulsion activities. This solar array has become the basis for a common solar array development program at Marshall designed to support not only the Solar Electric Propulsion System program, but also the 25 kW Power System. The currently planned first mission for the Solar Electric Propulsion System is a dual comet mission — a flyby of Halley's Comet in 1985 followed by a 1988 rendezvous with the comet, Tempel II.







ORIGINAL PAGE IS
OF POOR QUALITY

MANAGEMENT A

ID RESOURCES

Organization

The Marshall Center's organization structure is based on clear definition of functions to be performed. It is fitted to the Center's evolving mission, and has been substantially reconfigured in recent years to centralize and combine functions, shorten communication lines, and reduce organizational entities.

At the head of the organization is the Office of the Center Director. The director's staff offices provide specialized advice and support in such areas as personnel management and fiscal affairs.

Each of the formally established projects described in the Current Development Projects section of this book is managed by a project office responsible to the Center director. The project office responsibility includes the direction of both in-house design and development work, and also the management of a multiplicity of large and small contracts with private industry. Each provides planning, control, technical direction and review functions, and blend together the efforts of our own engineering laboratories with those of our contractors to form a team effort.

There are three major directorates within the Center structure. The job of the Program Development Directorate is to advance new ideas and to generate plans for promising new programs.

The Administration and Program Support Directorate consists of the organizations which maintain the physical plant and provide services such as procurement, operation of center computers, logistics, and security protection.

The third major organization is the Science and Engineering Directorate, which employs more than 50 percent of Marshall's people. This directorate is discipline-oriented and provides technical support to the various task teams and project offices. It also furnishes a research base for the advancement of technology.

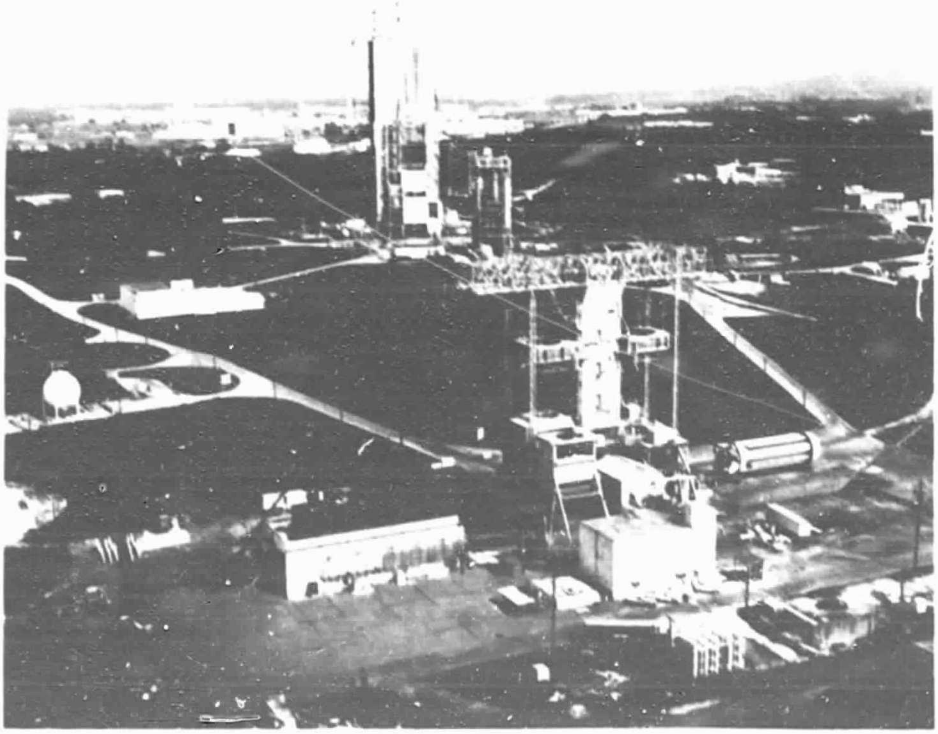
The Marshall Space Flight Center's streamlined structure has enabled it to meet the challenge of ever-rising costs with increased productivity.

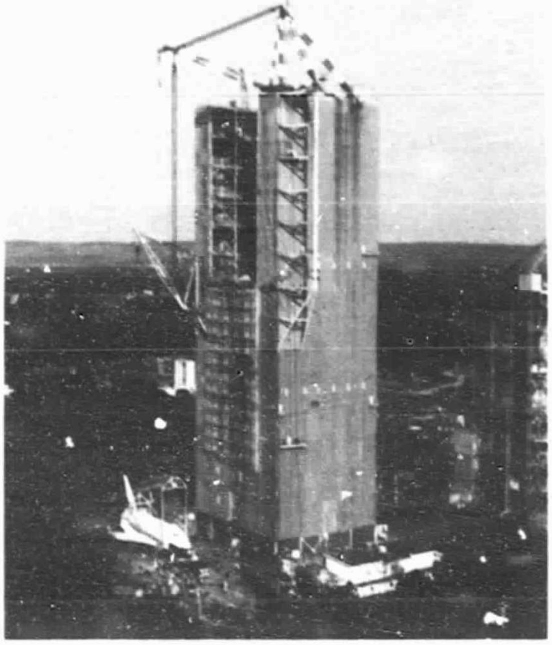
Facilities

Facilities worth more than $700 million are in use at Marshall-Huntsville and at its other installations. These include facilities for testing large space systems, facilities which are highly specialized, laboratories equipped for a wide variety of study, and off-site facilities available for the assembly of large space hardware and large systems propulsion testing.

A number of these facilities are unique within NASA. Some are not duplicated anywhere else in the nation or free world. The Marshall Center's major test facilities, for example, were built for the Apollo Saturn program. They were modified for use in Shuttle development at a fraction of the cost of new facilities. The Center's Science and Engineering laboratories are housed in 2.1 million square feet of combined office space, high bay area, lab space, and associated work areas.

Marshall's special facilities include a large X-ray telescope calibration and test system, an unusual Neutral Buoyancy Simulator, a special high-Reynolds-number wind tunnel, and a solar heating and cooling system and subsystem test facility.

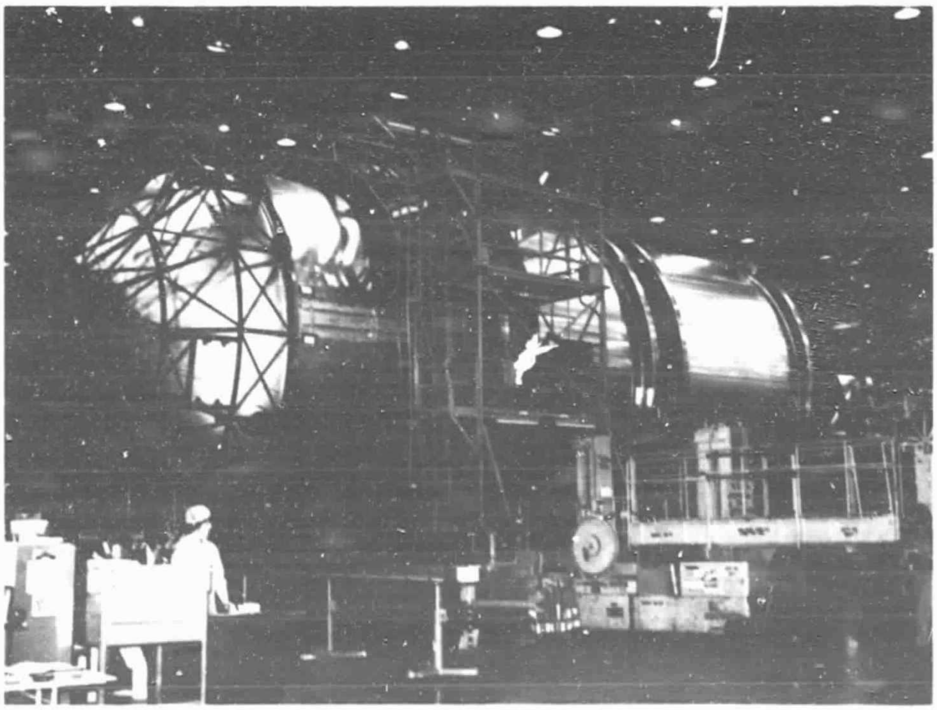




In New Orleans, Louisiana, Marshall's Michoud Assembly Facility is now being used to fabricate and assemble the External Tank for the Space Shuttle. This $130 million plant, which formerly produced Saturn rocket stages, provides a tremendous capability for the production and assembly of large space systems. Ready access at Huntsville to the Tennessee River, and Michoud's access to the Mississippi, means that the two sites are linked by economical barge transportation. Both also have access by deep-water transport to the launch facilities at Kennedy Space Center.

The Marshall Center also operates the $20 million Slidell Computer Complex at Slidell, Louisiana, to complement its Huntsville computer capability. Slidell provides Marshall, Michoud, and other NASA activities with critical automatic data processing services. The general purpose computation concept employed by Slidell serves to eliminate unnecessary duplication of facilities and computer equipment, and yields greater total capability than would be achievable with separate facilities at each location.

Marshall's many physical assets constitute a national resource, a ready resource which can be brought to bear on a wide variety of space-related projects within a short period of time.



People

Marshall's people, however, are its strongest assets. They are well-trained and unusually experienced.

This is also an exceptionally seasoned workforce. It is not unusual to find employees working on current projects, such as Space Shuttle, who also worked on the early Redstone/Jupiter projects that marked our country's entrance into the space age. Such experience is the rule, rather than the exception.

This talent and skill has enabled the Center to make the transition from the early rockets to Saturn; from Saturn to Skylab and the Lunar Roving Vehicle; from those programs to today's Space Shuttle, Space Telescope, Spacelab, High Energy Astronomy Observatories, Materials Processing in Space, and other payloads. These are farsighted people who have had a glimpse into the future and have seen a potential new world which reaps benefits available from space exploration.

They now are helping to build that world.